COLOR DOPPLER EVALUATION OF CEREBRAL UMBILICAL PULSATILITY RATIO AND ITS USEFULNESS IN THE DIAGNOSIS OF INTRAUTERINE GROWTH RETARDATION AND PREDICTION OF ADVERSE PERINATAL OUTCOME

Dissertation submitted to

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THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
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APRIL 2016

CERTIFICATE

This is to certify that the dissertation **COLOR DOPPLER EVALUATION OF CEREBRAL UMBILICAL PULSATILITY RATIO AND ITS USEFULNESS IN THE DIAGNOSIS OF INTRAUTERINE GROWTH RETARDATION AND PREDICTION OF ADVERSE PERINATAL OUTCOME** titled submitted by **Dr. V. DHEEBHA** appearing for **M.D (Radiodiagnosis)** degree examination in April 2016 is a bonafide record of work done by her under my guidance and supervision in partial fulfillment of requirement of the TamilNadu Dr. M.G.R Medical University, Chennai. I forward this to the TamilNadu Dr. M.G.R Medical University, Chennai.

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DECLARATION

I **Dr.V. DHEEBHA**, solemnly declare that this dissertation titled **"COLOR DOPPLER EVALUATION OF CEREBRAL UMBILICAL PULSATILITY RATIO AND ITS USEFULNESS IN THE DIAGNOSIS OF INTRAUTERINE GROWTH RETARDATION AND PREDICTION OF ADVERSE PERINATAL OUTCOME**" is a bonafide work done by me at the Barnard Institute of Radiology, Madras Medical College and Government General Hospital. This dissertation is submitted to The Tamil Nadu Dr. M.G.R Medical University, towards partial fulfillment of requirement for the award of M.D. Degree Radiodiagnosis.

Place: Chennai

Date: 30.9.2014 **Dr.V.Dheebha**

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INDEX

INTRODUCTION

Pregnancy is an intra uterine or extra uterine development of embryo or fetus with the support of maternal circulation. For a successful intra uterine pregnancy, good utero placental circulation is needed. “When the fetal biometry and fetal weight are less than the normal for gestational age , it is termed small for gestational age”. There are heterogenous group of small for gestational age fetuses.

This includes,

Fetuses with IUGR ,
Fetuses with appropriate growth wrongly diagnosed as small,
Fetuses with small for constitution

The small fetuses with normal Umbilical artery and middle cerebral artery (MCA) with out maternal pathology and Doppler ultrasound results are termed Small for gestational age (SGA).

The small fetuses with a recognizable maternal pathology or an abnormal UA or MCA Doppler ultrasound are termed growth-restricted fetuses.

When the growth of the fetus is less than 10^{th} percentile , it is known as intra uterine growth retardation.

‘Intrauterine growth restriction (IUGR)’ is a failure of the fetus to achieve its optimal growth potential. It constitutes a major clinical, social and public health problem, mainly in developing countries like India. Intra uterine growth retardation (IUGR) is associated with an increased risk of perinatal mortality, morbidity, and impaired neurodevelopment

USG:

USG biometry is used to differentiate heterogenous group of small for gestational age fetuses. Earlier identification of intra uterine growth retardation can be done with routine USG examination with fetal biometric measurements.

The most Common methods used for evaluation of fetal health in Small for gestational age (SGA) include bio physical profile, non stress test. Neither of these test is sensitive in predicting the outcome.

DOPPLER:

In obstetrics, Doppler ultrasound was introduced in 1977. In antenatal ultrasonography, the doppler represents an important diagnostic and screening tool.

Doppler studies shows changes associated with intra uterine growth retardation. The common parameters studied include Umbilical artery, middle cerebral arteries and uterine arteries. The values studied include peak systolic velocity, end diastolic velocity, resistive index,

pulsatility index , ratios of resistive and pulsatility indices of middle cerebral artery and umbilical artery.

Various studies show the significance of Doppler indices in predicting the adverse outcome of IUGR fetuses[6] and in differentiating IUGR fetuses from SGA fetuses. Doppler ultrasound has the potential to play a fundamental role in the diagnosis of IUGR .

Doppler USG enables a better identification of the hemodynamic changes associated with Placental insufficiency. So in high-risk pregnancies, it has become an important clinical tool for feto maternal surveillance and especially in prediction of peri natal outcome.[2]

The doppler also plays an important role in timing the delivery of some growth restricted fetuses. The correct detection of the compromised IUGR fetus to allow for timely intervention is a main objective of antenatal care .

In combination with biometry, doppler sonography of the UA and MCA provides the important tool to identify IUGR fetuses at risk for an adverse outcome.[19,20] Prediction of adverse perinatal outcomes helps the obstetricians to consider appropriate antenatal surveillance and therapeutic intervention

REVIEW OF LITERATURE

The development of a good utero-placental circulation is essential for the achievement of a normal pregnancy. Hence, **The Placental insufficiency is the most common cause of intrauterine growth retardation**.[1]

EMBRYOLOGY OF PLACENTA

PRECONCEPTION PREPERATION

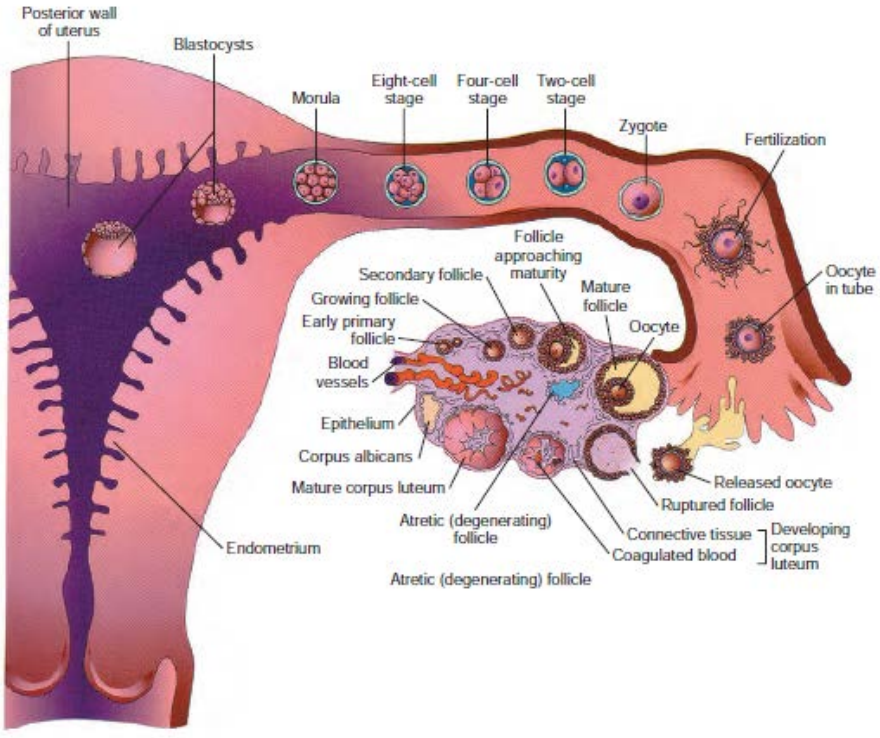
The hormones from the ovary prepare the uterine endometrium for the embryo in the each menstrual cycle. Endometrial proliferation occurs in response to estrogen secretion before ovulation .The endometrium becomes thickened, soft, and edematous under the influence of progesterone after ovulation. If pregnancy occurs, more marked hypertrophic changes in the endometrial cells and glands to provide nourishment to the blastocyst by the continued production of progesterone. These hypertrophic changes are referred to as the decidual reaction.

CONCEPTION AND IMPLANTATION

Oocyte is transported into the fimbriated end of the fallopian tube after ovulation. The sweeping movement of the fimbria, the currents produced by the cilia of the fallopian tube mucosal cells, and the

peristaltic waves from the fallopian musculature contractions all draw the oocyte into the tube.

Fertilization occurs about day 14 in the outer third of the fallopian tube as the mature ovum and sperm unite to form the zygote. During transit through the fallopian tube, cellular division of the zygote occurs. By day 17 when the conceptus enters the uterus, it is at the 12- to 15-cell stage (morula). The conceptus has matured into the blastocyst stage by day 20.

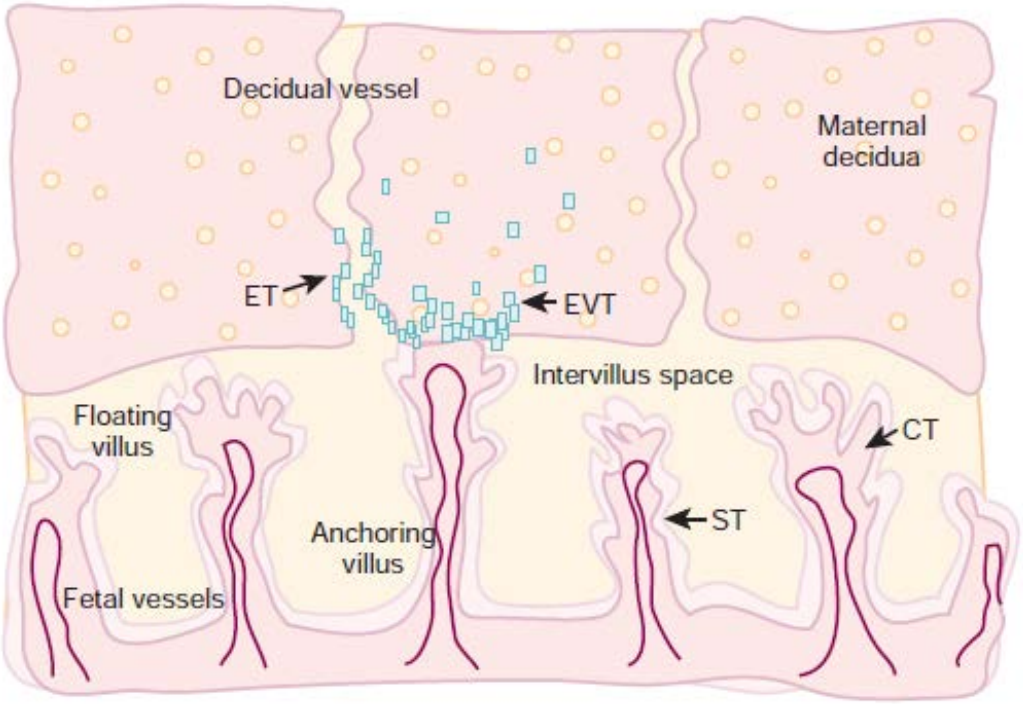


The blastocyst is lined with trophoblastic cells. It contains a cluster of cells at one side called the inner cell mass. The blastocyst at the site of the inner cell mass burrows through the endometrial membrane into the hyperplastic endometrium on day 20 and the implantation begins.

The implantation is completed by day 23. During implantation, the amniotic cavity forms with in the inner cell mass. The extra embryonic coelom becomes the chorionic cavity.

PLACENTAL DEVELOPMENT

The amnion and chorion surrounds the early developing embryo. The entire surface of the chorion is covered by the Villi up to about 8 weeks of gestation . The villi are the basic structures of the placenta. They initially form by 4 or 5 weeks gestation. The villi contiguous with the **decidua basalis** become the **chorion frondosum** . Later it become the placenta.



The chorionic platZe and chorionic villi constitute the fetal side of the placenta. The maternal side of the placenta consists of the decidua basalis. This decidua basalis opens up into large cisterns, the intervillous spaces. In the intervillous spaces, the fetal villi are immersed in the maternal blood.

DEVELOPMENT OF PLACENTAL CIRCULATION

The uterine spiral arteries dislodge the trophoblastic plugs during second trimester. After the vascular remodeling, the utero placental circulation starts. It becomes a low impedence, low pressure flow. It increases the total villous surface areas It establishes an adequate reservoir of nutrients and oxygen for developing fetus

Placental Size

At 18 to 20 weeks' gestation Placental length is approximately six times its maximal width. The mean thickness of the placenta in millimeters closely approximates the gestational age in weeks in the first half of pregnancy.

The use of ultrasound to evaluate the placenta is routine and important. There are wide range of pregnancy complications resulting from abnormal placental development. They include intrauterine growth

restriction (IUGR), preeclampsia, and abruption. Thus, careful examinations of the placenta by ultrasound can contribute directly to enhanced patient care and improved outcomes.

UMBILICAL CORD

Umblical cord has two arteries and one vein. The Umblical cord connects fetus with placental circulation. Oxygenated blood from the placenta is carried to the fetus through the umbilical vein. The umbilical arteries continues with the internal iliac arteries.

The development of adequate interface at the level of placenta between the maternal and fetal circulation is important for the adequate fetal growth.

INTRA UTERINE GROWTH RETARDATION:

"Intra uterine growth retardation is defined as effective fetal weight (EFW) of less than 10^{th} percentile for gestational age during pregnancy".

IUGR can be divided in to two types

1. Symmetrical IUGR
2. Asymmetrical IUGR

SYMMETRICAL IUGR:

In Symmetrical IUGR, for the gestational age ,all biometric measurements of fetus are lagging including head circumference (HC) and biparietal diameter (BPD).

ASYMMETRICAL IUGR:

In Asymmetrical IUGR Few biometric measurements of fetus are lagging compared to other measurements for the gestational age. Abdominal circumference (AC) lag relative to head circumference (HC) and biparietal diameter(BPD).

ETIOLOGY:

Placental insufficiency is the commonest cause .

1. Primary (placental cause)
2. Secondary to maternal factors(hypertension, poor nutrition, etc.)

PLACENTAL CAUSES:

Abnormal utero-placental circulation

Abnormal Feto-placental circulation

Primary placental disorder,

Abnormal cord insertion marginal / velamentous insertion of cord.

SECONDARY CAUSES - MATERNAL CONDITION:

GENETIC/CONSTITUTIONAL NUTRITION/STARVATION

Low pre pregnancy weight

Antiphospholipid Antibodies

Collagen vascular disease (systemic lupus erythematosus)

Inflammatory bowel disease

Chronic pancreatitis

VASCULAR

Chronic hypertension

Preeclampsia

Type 1 diabetes mellitus

OTHER CAUSES:

Poor Obstetric History,

Previous stillbirths,

Recurrent aborters,

Previous birth of growth-restricted fetus,

FETAL CAUSES

Chromosomal Abnormalities

Trisomy 13, 18, 21

Other syndroms : Seckel syndrome, Smith Lemli syndrome.

Intra uterine infection- Rubella, cytomegalo virus

CONGENITAL MALFORMATIONS

Omphalocele, Gastroschisis

Renal agenesis/dysplasia

MULTIPLE GESTATIONS

Monochorionic twins

Twin-to-twin transfusion

One fetus with malformations

Triplets and Discordant twins

PATHOPHYSIOLOGY:

Inhibited angiogenesis and poor placental adherence in first trimester leads to disturbance in placental vascular development. Inadequate invasion of trophoblastic plugs into maternal radial and spiral arteries in second trimester leads to failure of establishment of low resistance circuit. The Poor interface between the maternal and fetal circulation affect the nutrient and oxygen delivery.

The fetal responses are characterized by early and late cardio vascular adaptation. Early adaptation changes include change in distribution of blood flow in to essential organs especially the brain.

Fetal adaptations to UPI (Utero Placental Insufficiency)

1. Early cardio vascular adaptation
2. Late cardio vascular adaptation.

Early adaptation

There are changes in blood flow in response to fall in the blood flow distribution to essential organs- especially the brain. Umblical venous volume is reduced in early stages. This results in diversion of the umbilical venous blood into fetal heart through the foramen ovale. This blood reaches the left side of the heart finally it moves on to the coronary and cerebral circulation. There is associated increased pulmonary vascular resistance and placental resistance.

Late changes

Increasing placental resistance leads to the persistent reduction in the umbilicus venous volume this in turn results in the reduced fetal blood volume. This reduces the renal perfusion of the fetus resulting in oligohydromnios.

Rising after- load leads to reduced cardiac output. The final result is global myocardial dysfunction and dilatation. Fetal acidosis is an ominous finding. Spontaneous fetal heart rate deceleration and tricuspid regurgitation herald impending death.

Short and long term sequelae:

Fetus with intrauterine growth retardation has more risk of increased mortality, NEC, Respiratory distress syndrome when delivered as preterm.

When delivered as term baby, there is increased risks of transient tachypnoea of newborn, hypothermia, hypoglycemia, polycythemia, hyperbilirubinemia. In term IUGR risk of learning difficulty, behavioral problems, worse school performance are more. Preterm IUGR are at increased risk of neurodevelopmetal abnormality with cognitive impairment.

DIAGNOSTIC METHODS OF INTRA UTERINE GROWTH RETARDATION

ULTRA SOUND

Ultra sound is the high frequency sound waves with frequency more than 20,000 cycles per second. (20kHz). Ultrasound pulses of the type produced by the scanners include the frequency from 2 to 10 mHz.

The ultrasound waves are generated by a piezo electric transducer. This transducer changes the electrical signal to mechanical waves and receive the reflected ultrasound and change it back in to electrical signals. Transducers are both transmitters and receivers of ultrasound. The electrical signals are stored in computer.

Different modes of Ultra sound are available. It includes A Mode, B Mode, Real time, M Mode.

USG ASSESSMENT:

USG - PLACENTAL APPEARANCE:

The placenta is slightly more echogenic than the surrounding myometrium in the first and second trimesters. A small sinus called the marginal sinus of the placenta is noted in the edges of the placenta. It is the sinus where intervillous blood drains into the maternal venous

circulation. Areas of echogenicity and calcification within the placenta are visualized as the placenta matures.

GESTATIONAL AGE ASSESSEMENT

Gestational age assignment is important for dating the pregnancy and decide about the delivery. Usually Clinical dating of a pregnancy is based on the patient's recollection of the first day of her LMP and on the physical examination of uterine size. But both these methods are subject to imprecision. They usually lead to inaccuracies in gestational age assignment.

Dating by LMP (menstrual age) is usually inaccurate due to variability in length of menstrual cycles early or late ovulation, faulty memory, bleeding during early pregnancy.

Determining gestational age from the palpated dimension of the uterus may be inaccurate due to uterine fibroids, multiple pregnancy, and maternal body habitus.

ESTIMATION OF THE FETAL WEIGHT:

Estimation of the fetal weight especially in relation to the gestational age is important. It can influence the obstetric management decisions such as the timing and the route of delivery.

Eg

1. Early delivery may benefit a small for date fetus, as this fetus may be inadequately supplied by its placenta with oxygen and nutrients.
2. When the fetus is large, cesarean section may be the preferred route of delivery.

Considering these cases, the fetal measurements should be a component of every complete obstetric sonogram.

GESTATIONAL AGE ASSESSMENT IN FIRST TRIMESTER:

“The identification of a **gestational sac** in the uterine cavity is the earliest sign of an intrauterine pregnancy”.

With in the layer of echogenic rings formed by chorionic villi and the deeper layer of the decidua vera, they are usually seen as a round or oval fluid collection. It is first seen at approximately 5 weeks' gestation.

After 5 to 6 weeks' gestation, two methods are used for gestational age assessment by ultrasound:

(1) Measurement of mean sac diameter (MSD) (average internal diameter of the gestational sac)

(2) Sonographic identification of gestational sac contents.

MEASUREMENT OF MEAN SAC DIAMETER (MSD

The gestational sac is first identifiable at 5.0 weeks. It can be used to assign gestational age during this period.

The mean sac diameter is the mean of the anteroposterior (AP) diameter, the longitudinal diameter and the transverse diameter. It increases from 2 mm at 5 weeks to 10 mm at 6 weeks.

SONOGRAPHIC IDENTIFICATION OF GESTATIONAL SAC CONTENTS

Best done by transvaginal sonography.

Visualisation of

Yolk sac - 5.5 weeks .

Embryo and it's heartbeat - 6.0 weeks

Embryo 5 mm or greater in length - 6.3 weeks. From 6 weeks onwards. Gestational age can be assigned based on the crown-rump length. The Gestational age correlates closely with the crown-rump length (CRL) of the embryo or fetus. The CRL can be used to assign gestational age accurately up to 11 weeks.

SECOND AND THIRD TRIMESTERS

The sonographic parameters proposed for estimating gestational age in the second and third trimesters include biparietal diameter (BPD), head circumference (HC), femur length (FL), length of other long bones, abdominal circumference (AC), and binocular distance and combinations of two or more fetal measurements: the corrected-BPD and composite age formulas.

LATE PREGNANCY - DETERMINATION OF GESTATIONAL AGE:

When a clinician is first confronted, a pregnant woman who has already reached the third trimester and is uncertain of her dates, it is very difficult to predict her gestational age accurately.

Various measures are used to assess the gestational age of the fetus.

1. It includes long bone ossification centres.

The distal femoral epiphysis is observed in 94% of the fetus at 34 weeks of gestational age (not seen before 28 weeks of gestational age) .

The posterior tibial epiphysis is seen in 35% of fetuses of 35 weeks old and 80% of fetuses of 37 weeks of gestational age.

2. Length of foot and the transverse diameter of the cerebellum (Spared in IUGR).

3. Additional measures include placental grading, colonic echogenicity and the presence or absence of haustra of colon and small intestinal peristalsis.

SONOGRAPHIC DIAGNOSIS OF IUGR

In modern obstetric practice ,the Ultra sound has become the essential tool. It is crucial for the assessment of the placenta, membranes, fluid and fetal anomaly. USG has become superior than clinical examination in determining fetal growth, fetal age, adequacy of fetal interval growth. With Doppler technology fetal status can be assessed to determine pathology earlier. Doppler USG has become important for making management decision in high risk settings.

BIOMETRIC MEASUREMENTS.

Biometric measurements can be calculated by optimizing the image, choosing the correct section fetus and by placing the cursors in correct end points of measurements

FETAL HEAD

The measurements done in fetal head includes Biparietal diameter, occipito frontal diameter (OFD), corrected- Biparietal diameter, and head circumference.

BIPARIETAL DIAMETER

For Biparietal diameter any plane of section through 360 degree arc that passes through third ventricle and thalami is selected.

The calvaria should be bilaterally smooth and symmetrical. The cursors are consistently positioned in either of three ways.

1. Inner Edge of near calvarial wall to outer edge of far calvarial wall
2. The outer edge of near calvarial wall to inner edge of far calvarial wall.
3. Middle of near calvarial wall to middle of far calvarial wall.

The occipitofrontal diameter (OFD) is measured as the BPD from the same trans axial image and is measured from mid skull to mid skull along the long axis of the fetal head.

Corrected BPD is measured from the OFD

Corrected BPD

FEMUR LENGTH

For Femur Length measurement, the transducer need be aligned to the long axis of the bone. This is ensured by demonstrating that both the femoral head and the greater trochanter and the femoral condyle are in the plane of section.

The cavus has to be placed at the junction of the cartilage and the bone. The bright thin reflection of the cartilaginous epiphysis should not be included in the measurement.

ABDOMINAL CIRCUMFERENCE

For AC the plane of section is at the level where the right and left portal veins are continous with one another. This is known as hockey stick. The fetal AC is the length of the outer perimeter of the fetal abdomen, measured on transverse scan at the level of the stomach and intrahepatic portion of the umbilical vein.

The appearance of the lower rib is symmetric. The shortest length of the umbilical segment of the left portal vein is depicted finally. The eclipse is fit to the skin edge.

ESTIMATION OF FETAL WEIGHT

The accuracy of formula for weight prediction improves when the number of measured body parts increases up to three, achieving greatest accuracy when measurements of the head, abdomen, and femur are used.

A number of factors have been studied to determine their effect on accuracy of weight prediction.

Weight- (Accuracy is worse in fetuses with weight of < 1000gm .

Scan quality – (good scan quality have good accuracy)

Maternal diseases- (Less accurate in diabetic than in nondiabetic mothers)

All three key fetal anatomic regions should be measured—head, abdomen, and femur—at the appropriate anatomic levels. If both the head and the femur cannot be measured or the abdominal circumference cannot be measured, the weight estimate should not be calculated.

FORMULA 1:

If measurements of all three (head, abdomen, and femur) structures can be obtained, Formula 1 should be used to estimate fetal weight.

When the OFD is available this formula should be used with the corrected-BPD, and When the OFD is not available, the BPD itself is used.

Log 10 (EFW) = "1.4787 - 0.003343 AC X FL + 0.001837 BPD2 + 0.0458AC+.0158 FL"

FORMULA 2:

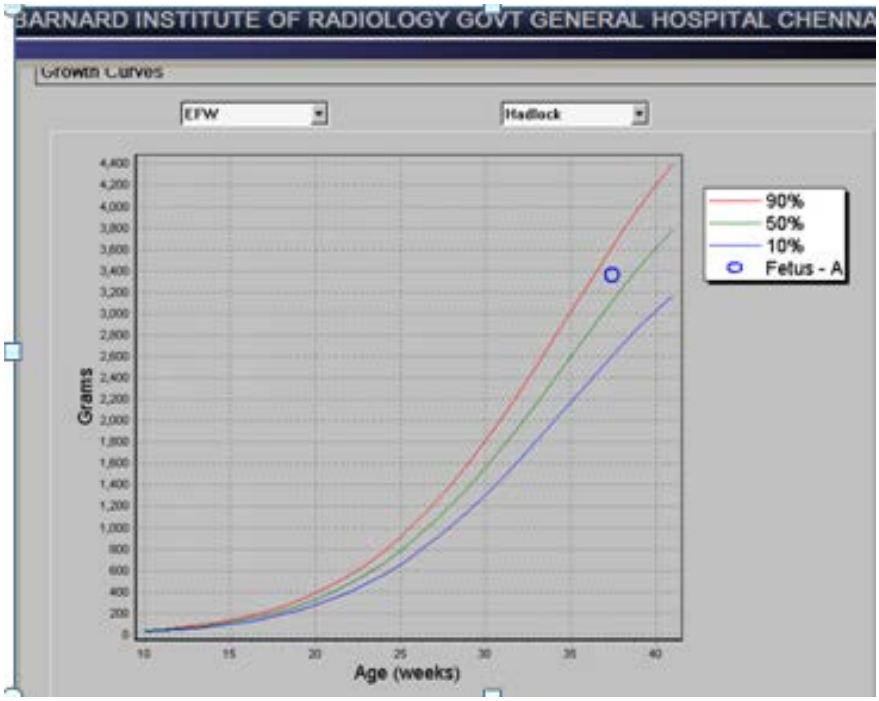
If the abdomen and only the head or the femur can be appropriately imaged,

"Log10 (EFW) = 1.3598 + 0.051 AC + 0.1844 FL − 0.0037 AC × FL"

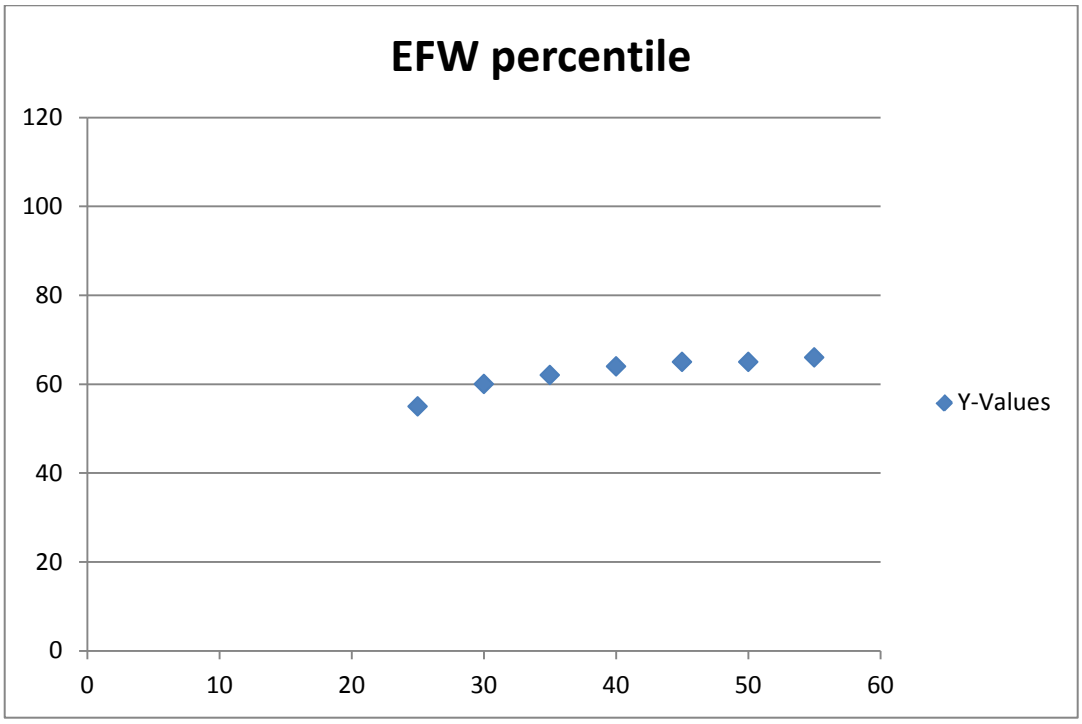
FETAL GROWTH CURVES

Fetal growth can be depicted graphically after several examinations, by means of a trend plot, or growth curve.

One growth curve plots the **gestational age versus estimated fetal weight.** The fetus weight curve is superimposed on lines depicting the 1st, 10th, 50th, 90th, and 99th percentiles.



2. An alternative growth curve display plots the **estimated weight percentile versus gestational age** . In this format, the graph for a normally growing fetus is a horizontal line, indicating maintenance of a particular weight percentile throughout gestation. A downsloping line indicates a subnormal growth rate, and an upsloping line indicates accelerated growth.



Calculation of weight percentiles and plotting of growth curves is most easily accomplished by computer,using an obstetric ultrasound software package that performs these tasks

SONOGRAPHIC CRITERIA FOR INTRA UTERINE GROWTH RESTRICTION (IUGR) - CONVENTIONAL

The key parameters used in combination to establish the diagnosis of IUGR with greater certainty include

Estimated fetal weight

Amniotic fluid volume

Maternal blood pressure status (normal vs. hypertensive

CRITICAL VALUES FOR ESTIMATED FETAL WEIGHT (IN GRAMS) FOR DIAGNOSING OR EXCLUDING INTRAUTERINE GROWTH RESTRICTION

Two values for any gestational age are presented in the table. The values depends on subjectively assessed Amniotic fluid volume , and maternal blood pressure status

	Status of Maternal Blood Pressure and Amniotic Fluid Volume					
GA WK	**NL BP NL/POLY**	**NL BP M-M OLIGO**	**NL BP SEV OLIGO**	**HTN NL/POLY**	**HTN M-M OLIGO**	**HTN SEV OLIGO**
26	516-660	646-826	743-950	610-780	763-976	878-1123
27	597-761	745-949	855-1090	704-898	878-1119	1009-1285
28	693-877	859-1087	982-1244	813-1030	1008-1276	1153-1460
29	803-1008	988-1239	1124-1410	937-1176	1152-1446	1312-1646
30	931-1155	1132-1405	1281-1589	1078-1337	1311-1627	1483-1840
31	1075-1317	1293-1584	1452-1779	1234-1512	1484-1819	1667-2042
32	1235-1493	1468-1774	1635-1976	1405-1698	1670-2018	1860-2248
33	1411-1682	1656-1973	1830-2180	1590-1895	1865-2223	2061-2456
34	1600-1880	1853-2177	2031-2386	1785-2098	2067-2429	2266-2662
35	1798-2083	2055-2382	2236-2590	1987-2302	2272-2633	2471-2863
36	1997-2285	2257-2583	2437-2789	2189-2504	2474-2830	2671-3056
37	2192-2479	2452-2774	2631-2976	2383-2696	2666-3016	2861-3236
38	2371-2658	2631-2949	2807-3147	2563-2872	2843-3186	3034-3400
39	2526-2812	2785-3101	2961-3296	2717-3025	2996-3335	3185-3545
40	2645-2933	2906-3223	3083-3419	2838-3147	3118-3458	3307-3668
41	2717-3013	2985-3310	3166-3511	2915-3232	3202-3551	3396-3766
42	2736-3045	3016-3356	3205-3567	2942-3274	3243-3609	3447-3836

From Benson CB, Belville JS, Lentini JF, et al. Intrauterine growth retardation: diagnosis based on multiple parameters: a prospective study. Radiology 1990;177:499-502.
*For each pair, estimated weight less than the lower value allows confident diagnosis of intrauterine growth restriction (IUGR; positive predictive value, 74%). Estimated weight greater than the upper value virtually excludes IUGR (negative predictive value, 97%). Estimated weight between the two values is indeterminate for IUGR (likelihood of IUGR, 13%).
GA, Gestational age; *NI BP*, normal blood pressure; *Htn*, hypertension; *NL*, normal fluid; *Poly*, polyhydramnios; *M-M*, mild to moderate; *Olign*, oligohydramnios; *Sev*,

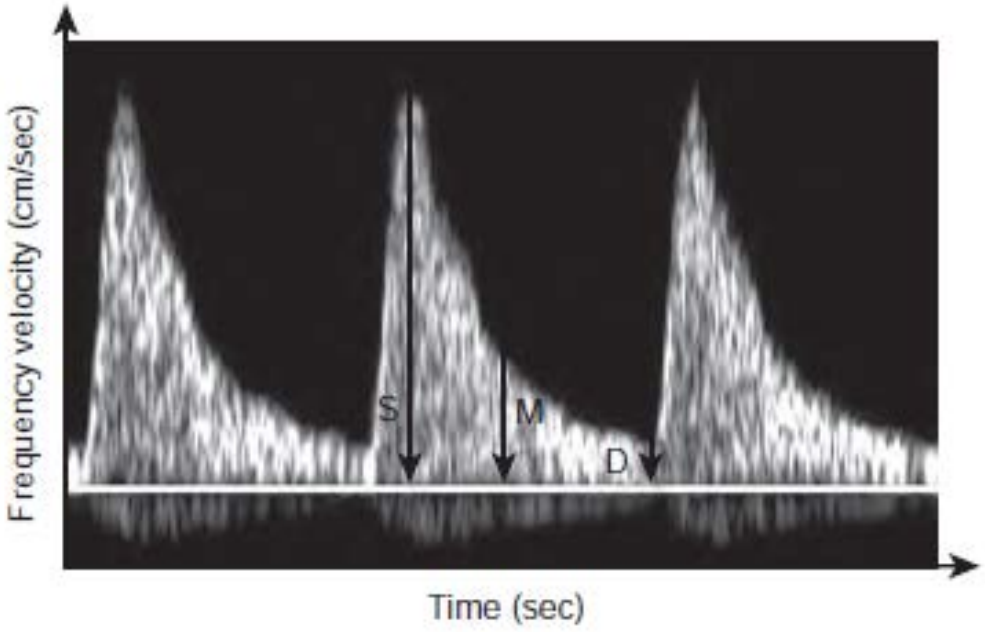
USE OF THE GROWTH TABLE

IUGR can be diagnosed with confidence, when a fetus has an estimated weight below the smaller value. Growth restriction can be excluded, when the estimated weight is above the larger value. If the estimated weight between smaller and larger values, it is indeterminate for IUGR.

DOPPLER ULTRASOUND DURING PREGNANCY:

DOPPLER WAVE FORM

Doppler waveforms reflect blood velocity. Doppler waveforms also provide information on various blood flow pattern in circulation. It includes velocity Profile, the presence and direction of flow, volume of flow, and impedance to flow. These waveforms are used for assessing downstream circulatory impedance. The condition essential for the assessment of true velocity depends on the angle between the ultrasound beam and the direction of the blood flow. The angle has to be as close as possible to 0 degrees.



S- Peak systolic velocity. M – Mean velocity. D- End diastolic velocity.

FACTORS AFFECTING THE DOPPLER FLOW VELOCITY WAVE FORMS

Maternal position

Fetal breathing movements

Blood viscocity

Fetal heart rate

The following angle-independent indices are used:

1. **Systolic-to-diastolic** (S/D) **ratio**

   Peak systolic velocity/End diastolic velocity (PSV/EDV)

2. **Resistive index** (RI) (PSV −EDV)/PSV

3. **Pulsatility index** (PI) (PSV −EDV) / Mean velocity

All three indices provide information on vascular impedance. Vascular impedence depends on vascular resistance, preload, heart rate, and cardiac contractility.

By estimating the vascular resistance by calculating any one of these indices ((S/D) ratio PI Ratio, RI ratio), the amount of blood flow can be obtained. Assessment of the PI in Doppler ultrasound studies of the fetal cardiovascular system leads to understanding of redistribution of blood flow in fetus.

NORMAL DOPPLER CHANGES DURING PREGNANCY

Adequacy of Utero placental perfusion can be studied indirectly by uterine artery, umbilical artery and middle cerebral artery Doppler studies. The uterine artery ,fetal umbilical and middle cerebral arterial and fetal venous Doppler velocimetry is a non-invasive Technique. So they can be easily added to the current routine ultrasound examination

MCA causes 80% of the cerebral blood flow. High impedance circulation is noted in the MCA with a continuous forward flow .

The ability of Doppler study to determine a group of at-risk patients makes it potential screening tool in predicting adverse pregnancy outcome

METHODS OF DOPPLER MEASUREMENT UTERINE ARTERY

In normal pregnancy, the uterine artery resistance decreases with advancing gestational age. In early pregnancy, the Doppler ultrasound studies of the uterine artery is used as a screening tool for pregnancies destined to develop preeclampsia or IUGR. Indications for the assessment of the uterine artery Doppler ultrasound

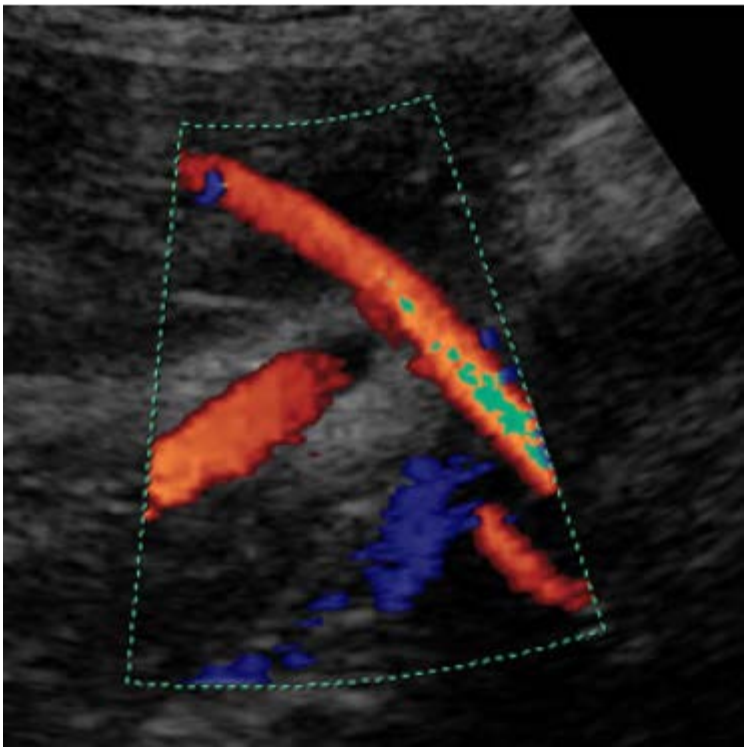
(1) previous child with IUGR

(2) previous history of preeclampsia,

(3) high human chorionic gonadotropin levels.

SITE OF MEASUREMENT

Each uterine vessel can be assessed by color Doppler as it crosses over the hypogastric artery and vein. Doppler velocity should be obtained at uterine artery before the vessel divides in to uterine and cervical branches immediately after it crosses the hypogastric artery



Colour Doppler image of uterine artery crossing the iliac vessels.

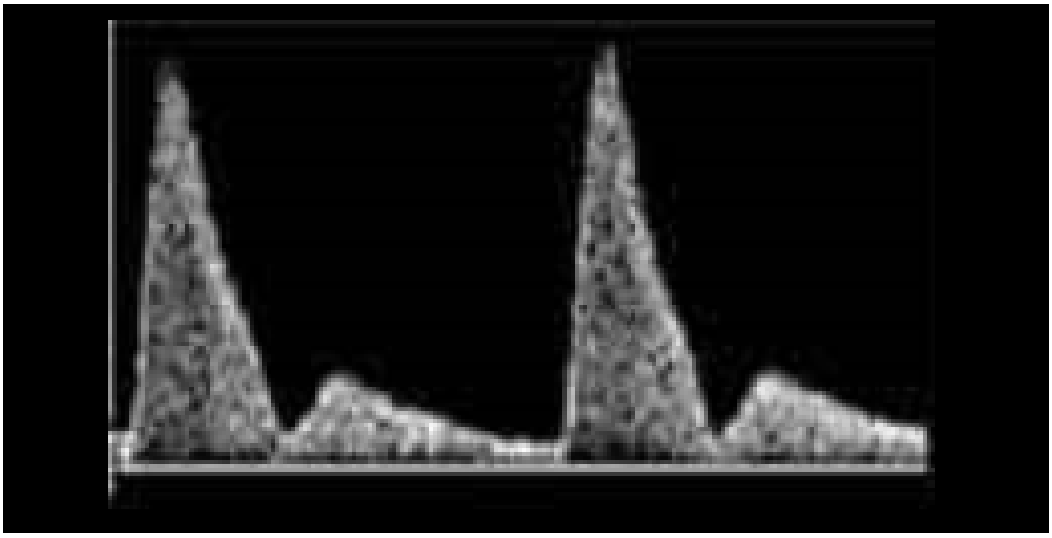
NORMAL UTERINE ARTERY FLOW

In a non gravid state and at early pregnancy, the flow in uterine artery is of with a high systolic flow and low diastolic flow (high pulsatility). A physiological early diastolic notch may be present.

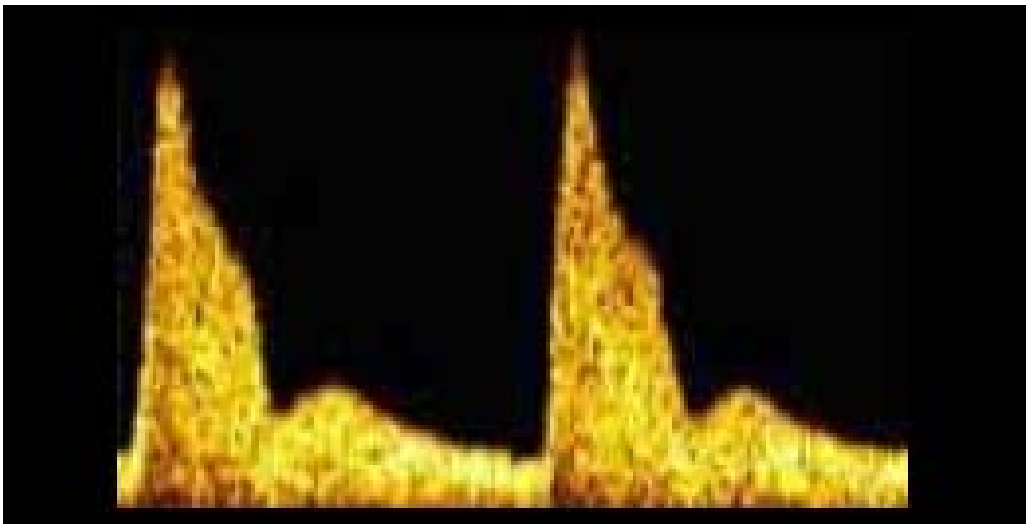
The normal uterine arterial blood flow in non pregnant women is 50 mL per minute. In the third trimester of pregnancy, the increase in uterine artery flow is over 700 mL per min. They are less responsive to sympathetic and para sympathetic system.

The uterine artery waveform is therefore characterized by high end diastolic velocities (EDVs) by the mid– second trimester by 18 to 22 weeks. [18] It is associated with continuous forward blood flow throughout diastole. The degree of end diastolic flow typically increases with advancing gestation.

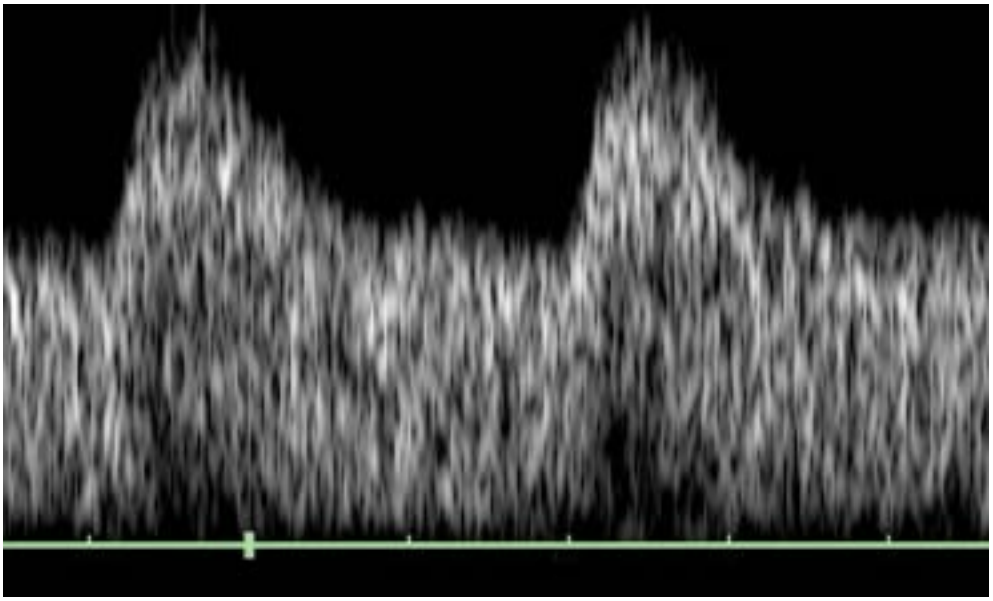
These waveforms are quantified by indices such as PI, RI and notching of one or both uterine arteries.



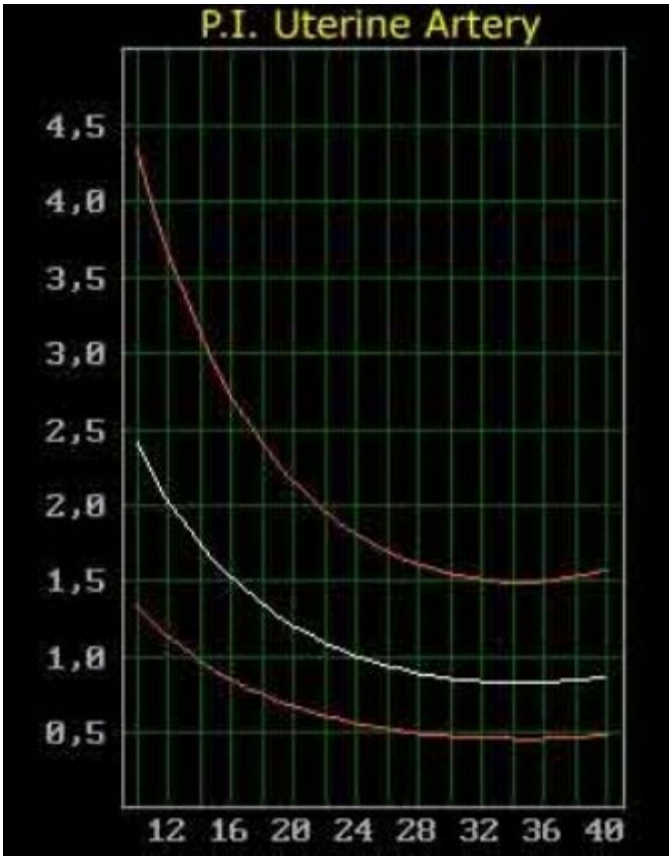
Uterine artery wave form in first trimester - Normal impedance to flow.



Uterine artery wave form in 2nd trimester - Normal impedance to flow .



Normal Uterine Artery Wave with High Diastolic Flow (at 24 weeks of gestation.)



Reference values of PI Of Uterine Artery

Table 22–8 Pulsatility Index of the Uterine Artery

Gestation (wks)	5th Percentile	50th Percentile	95th Percentile
18	0.509	0.888	1.407
19	0.460	0.838	1.356
20	0.436	0.812	1.328
21	0.420	0.795	1.309
22	0.407	0.781	1.293
23	0.397	0.769	1.280
24	0.388	0.759	1.268
25	0.381	0.751	1.258
26	0.374	0.743	1.248
27	0.369	0.736	1.239
28	0.363	0.729	1.230
29	0.358	0.722	1.222
30	0.354	0.716	1.214
31	0.349	0.711	1.207
32	0.345	0.705	1.199
33	0.341	0.700	1.192
34	0.337	0.695	1.185
35	0.333	0.690	1.178
36	0.330	0.684	1.171
37	0.326	0.679	1.164
38	0.322	0.674	1.157
39	0.318	0.669	1.150
40	0.313	0.663	1.143

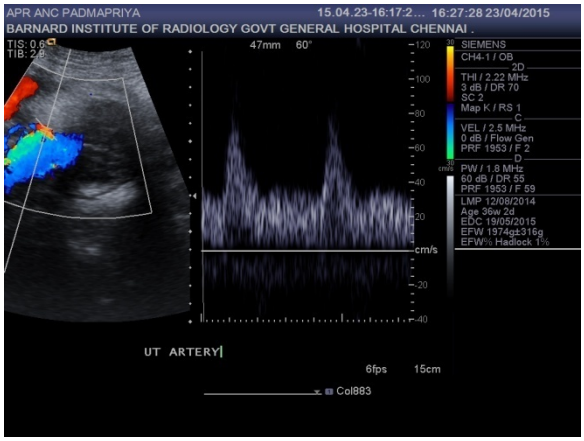
From Merz E (ed): Ultrasonography in Obstetrics and Gynecology, vol 1. Stuttgart, New York, Thieme, 2005, pp 469–480, 614.

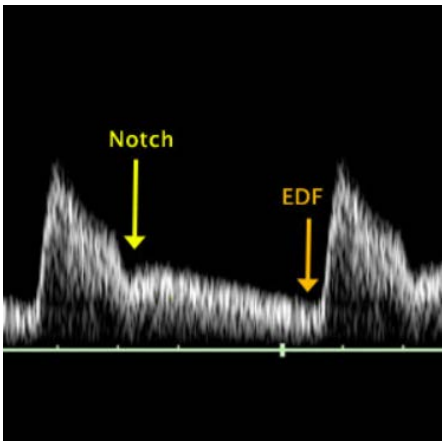
Pulsatility index in the uterine artery with gestation (mean 95th and 5th centiles).

Reference values of RI Of Uterine Artery

Gestation (wks)	5th Percentile	50th Percentile	95th Percentile
18	0.222	0.447	0.659
19	0.204	0.429	0.641
20	0.194	0.419	0.630
21	0.186	0.411	0.622
22	0.180	0.405	0.615
23	0.175	0.400	0.610
24	0.171	0.395	0.605
25	0.167	0.391	0.601
26	0.163	0.387	0.597
27	0.160	0.384	0.593
28	0.157	0.380	0.590
29	0.154	0.378	0.587
30	0.152	0.375	0.584
31	0.150	0.372	0.581
32	0.147	0.370	0.578
33	0.145	0.368	0.576
34	0.144	0.366	0.574
35	0.142	0.364	0.571
36	0.140	0.362	0.569
37	0.139	0.360	0.567
38	0.137	0.358	0.566
39	0.136	0.357	0.564
40	0.135	0.355	0.562

From Merz E (ed): Ultrasonography in Obstetrics and Gynecology, vol 1. Stuttgart, New York, Thieme, 2005, pp 469–480, 614.



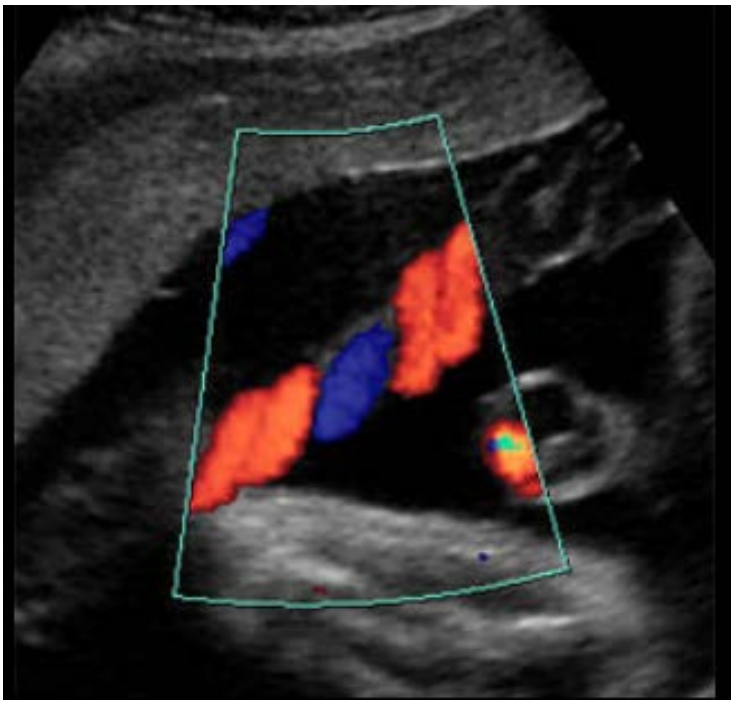


Uterine artery waveform in impaired placentation (24 weeks of gestation) A notch in early diastole, Decreased flow in late diastole.

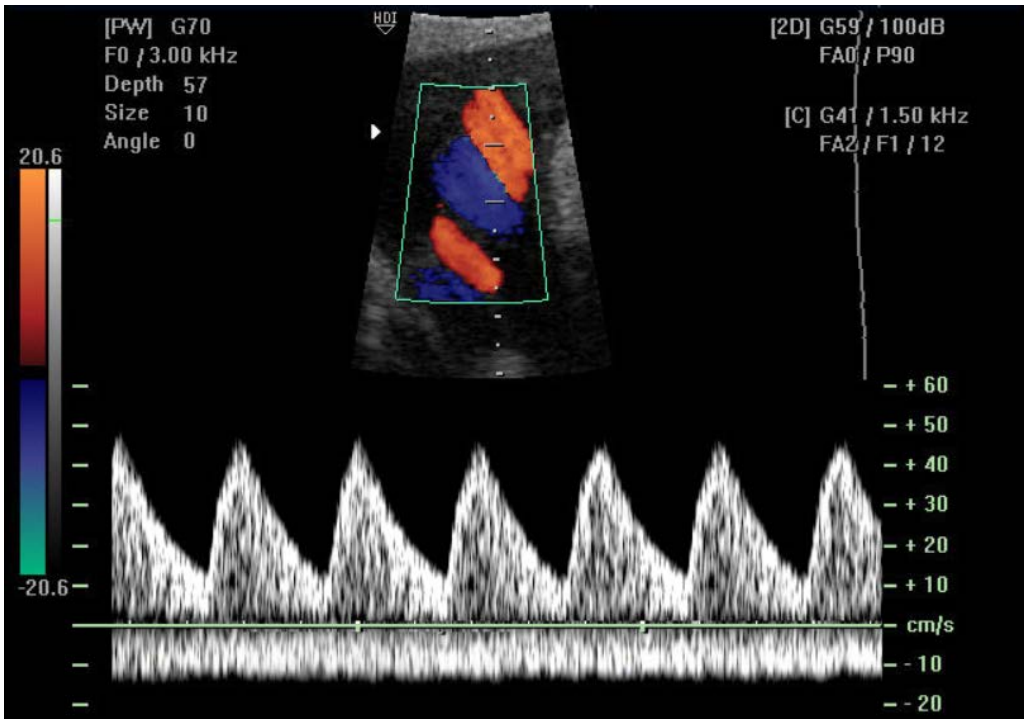
UMBLICAL ARTERY

Doppler waveform can be obtained from any segment along the umbilical cord. Wave form from the placental end of the umbilical cord show more end diastolic flow.[24]

During the early second trimester, a diastolic component in the umblical artery flow velocity waveform (FVW) appears, i.e.at 15 weeks' gestation.[3] The diastolic component progressively increases with an increase in the gestational age[16.] A mature umblical artery FVW is usually achieved by 28- 30 weeks.[3] With advancing gestation, the normal umblical artery waveform pattern shows low impedance and high end diastolic flow with a low PI.[7]



COLOUR DOPPLER IMAGE OF UMBLICAL ARTERY.



Normal flow velocity waveforms of UA at 32 weeks of gestation.

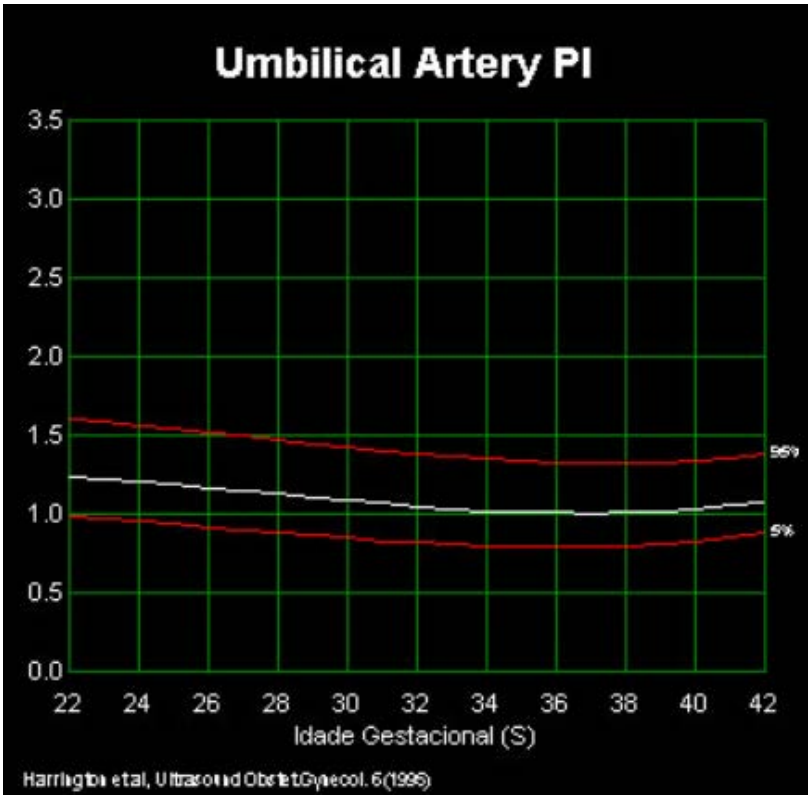
Reference Values Of Serial Measurement Of UMB RI Ratio And PI Ratio.

Gestation (wks)	5th Percentile	50th Percentile	95th Percentile
20	0.567	0.690	0.802
21	0.557	0.680	0.793
22	0.548	0.671	0.784
23	0.539	0.663	0.776
24	0.530	0.655	0.768
25	0.522	0.646	0.760
26	0.514	0.639	0.752
27	0.506	0.631	0.745
28	0.498	0.623	0.737
29	0.490	0.615	0.730
30	0.482	0.608	0.723
31	0.474	0.600	0.715
32	0.465	0.592	0.707
33	0.457	0.584	0.700
34	0.449	0.576	0.692
35	0.440	0.567	0.684
36	0.431	0.559	0.675
37	0.422	0.550	0.667
38	0.412	0.540	0.657
39	0.402	0.530	0.648
40	0.390	0.519	0.637

From Merz E (ed): Ultrasonography in Obstetrics and Gynecology, vol 1. Stuttgart, New York, Thieme, 2005, pp 469–480, 614.

Gestation (wks)	5th Percentile	50th Percentile	95th Percentile
20	0.940	1.216	1.505
21	0.913	1.189	1.476
22	0.890	1.165	1.450
23	0.869	1.142	1.427
24	0.849	1.122	1.405
25	0.831	1.102	1.385
26	0.813	1.084	1.365
27	0.798	1.065	1.346
28	0.780	1.048	1.327
29	0.764	1.031	1.308
30	0.748	1.014	1.290
31	0.732	0.997	1.272
32	0.716	0.980	1.254
33	0.700	0.963	1.236
34	0.684	0.946	1.218
35	0.668	0.928	1.199
36	0.651	0.910	1.180
37	0.634	0.891	1.160
38	0.615	0.872	1.139
39	0.595	0.851	1.117
40	0.573	0.828	1.093

From Merz E (ed): Ultrasonography in Obstetrics and Gynecology, vol 1. Stuttgart, New York, Thieme, 2005, pp 469–480, 614.



Pulsatility index in the umbilical artery with gestation (mean, 95th and 5th centiles).

Reference Values Of Serial Measurement Of UMB SD Ratio

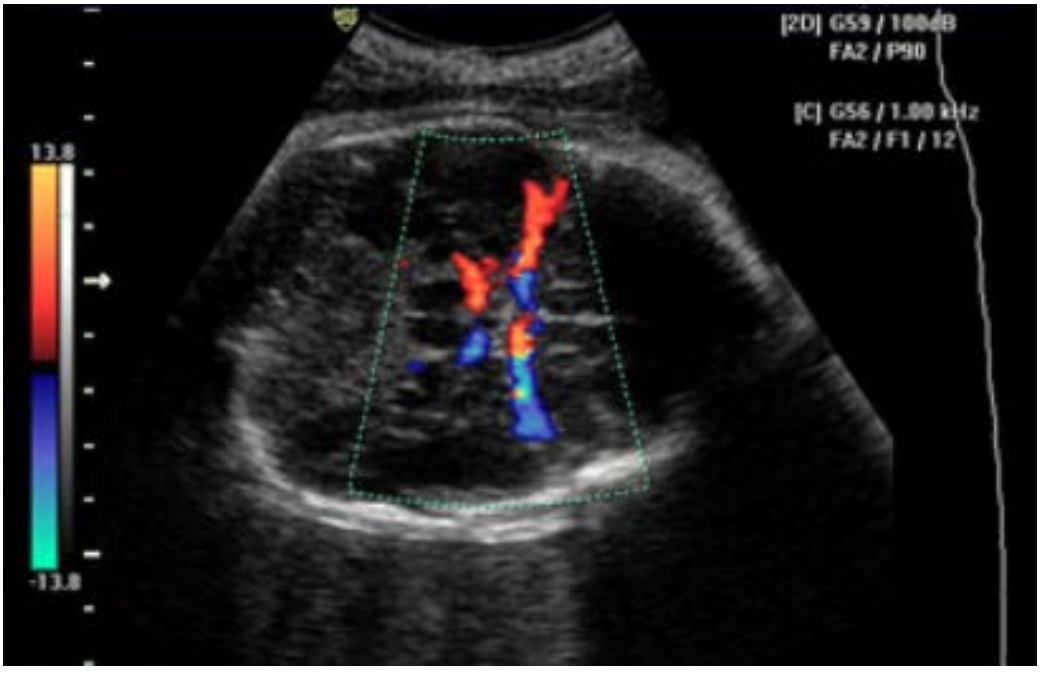
	Percentile							
Gestation (wk)	2.5th	5th	10th	25th	50th	75th	90th	95th
19	2.73	2.93	3.19	3.67	4.28	5.00	5.75	6.26
20	2.63	2.83	3.07	3.53	4.11	4.80	5.51	5.99
21	2.51	2.70	2.93	3.36	3.91	4.55	5.22	5.67
22	2.43	2.60	2.83	3.24	3.77	4.38	5.03	5.45
23	2.34	2.51	2.72	3.11	3.62	4.21	4.82	5.22
24	2.25	2.41	2.62	2.99	3.48	4.04	4.63	5.02
25	2.17	2.33	2.52	2.88	3.35	3.89	4.45	4.83
26	2.09	2.24	2.43	2.78	3.23	3.75	4.30	4.66
27	2.02	2.17	2.35	2.69	3.12	3.63	4.15	4.50
28	1.95	2.09	2.27	2.60	3.02	3.51	4.02	4.36
29	1.89	2.03	2.20	2.52	2.92	3.40	3.89	4.22
30	1.83	1.96	2.13	2.44	2.83	3.30	3.78	4.10
31	1.77	1.90	2.06	2.36	2.75	3.20	3.67	3.98
32	1.71	1.84	2.00	2.29	2.67	3.11	3.57	3.87
33	1.66	1.79	1.94	2.23	2.60	3.03	3.48	3.77
34	1.61	1.73	1.88	2.16	2.53	2.95	3.39	3.68
35	1.57	1.68	1.83	2.11	2.46	2.87	3.30	3.59
36	1.52	1.64	1.78	2.05	2.40	2.80	3.23	3.51
37	1.48	1.59	1.73	2.00	2.34	2.74	3.15	3.43
38	1.44	1.55	1.69	1.95	2.28	2.67	3.08	3.36
39	1.40	1.51	1.64	1.90	2.23	2.61	3.02	3.29
40	1.36	1.47	1.60	1.85	2.18	2.56	1.96	3.22
41	1.33	1.43	1.56	1.81	2.13	2.50	2.90	3.16

From Acharya G, Wilsgaard T, Berntsen GKR, et al: Reference ranges for serial measurements of umbilical artery Doppler indices in the second half Am J Obstet Gynecol 192:937, 2005.

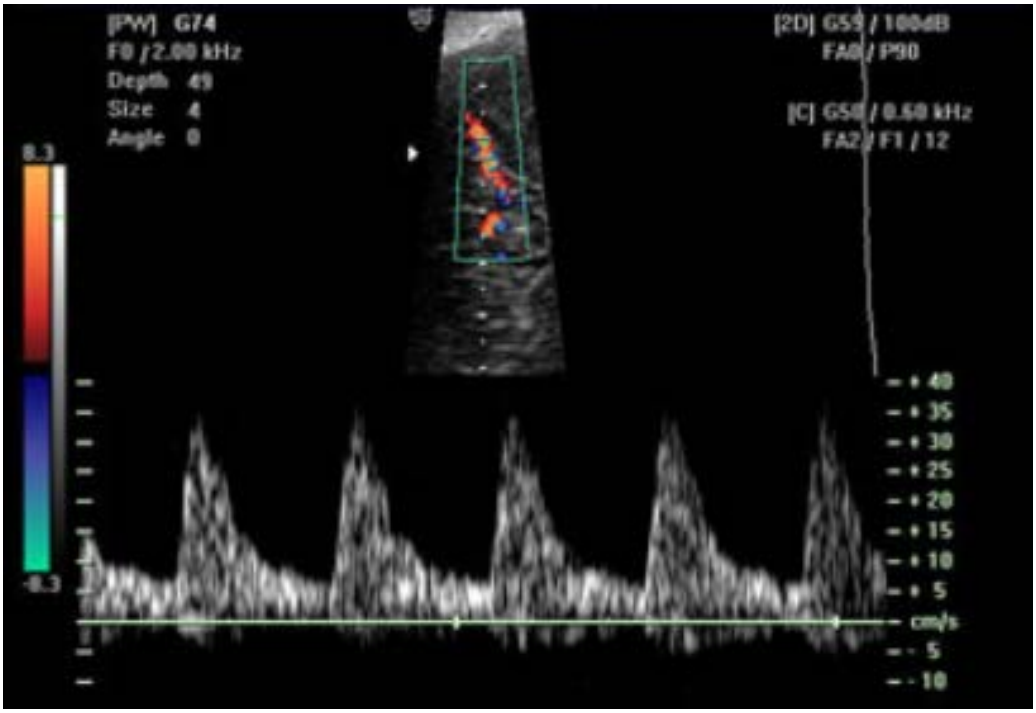
MIDDLE CEREBRAL ARTERY

The right and left MCA are the major brances of the circle of Willis. The circle of Willis can be imaged with color flow Doppler USG in a transverse plane of the base of the skull. In transverse plane of the base of the fetal skull the proximal and distal MCA are almost parallel to the ultra sound beam.

The insonating beam is parallel to the vessel. It has a cosine of 0 degree. This results in a measured velocity. Doppler wave form are obtained from the proximal MCA immediately after its origin from the circle of Willis. The MCA PSV progressively increases with advancing gestation in all fetuses.[14]

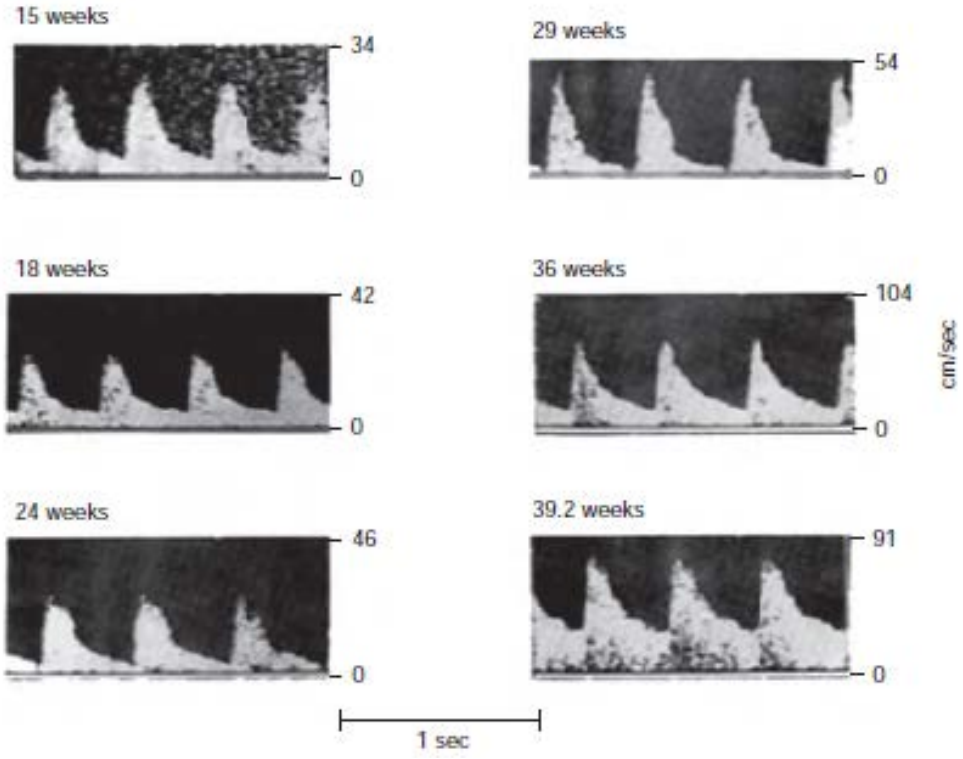


Doppler showing the circle of Willis - Transverse view of the fetal head.



Middle cerebral artery wave forms at 32 weeks of gestation.

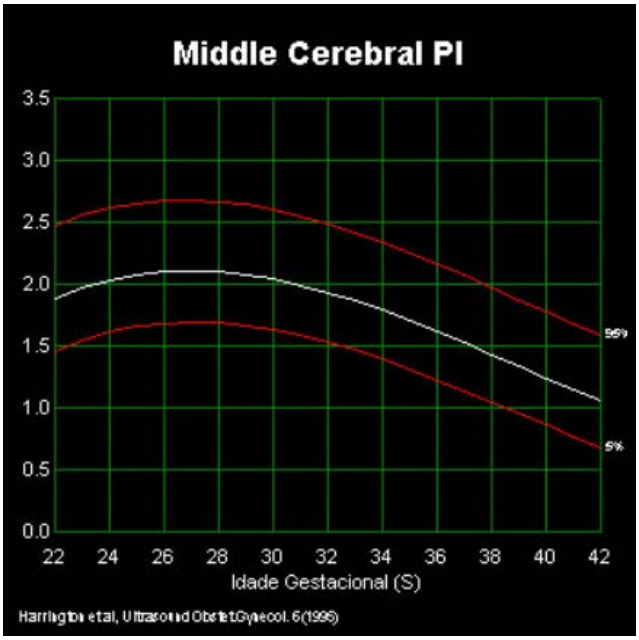
Normal middle cerebral artery flow in various gestational age.



Reference values of MCA PI Values

GA (week)	Normal Values		
	LOWER LIMIT†	PREDICTED VALUE	UPPER LIMIT‡
15	0.99	1.57	2.14
16	1.08	1.71	2.33
17	1.16	1.83	2.51
18	1.23	1.95	2.67
19	1.30	2.05	2.81
20	1.35	2.14	2.93
21	1.40	2.22	3.04
22	1.44	2.29	3.13
23	1.48	2.34	3.20
24	1.51	2.38	3.26
25	1.52	2.41	3.30
26	1.54	2.43	3.32
27	1.54	2.44	3.33
28	1.54	2.43	3.32
29	1.52	2.41	3.30
30	1.50	2.38	3.26
31	1.48	2.34	3.20
32	1.44	2.28	3.12
33	1.40	2.21	3.03
34	1.35	2.13	2.92
35	1.29	2.04	2.79
36	1.22	1.94	2.65
37	1.15	1.82	2.49
38	1.07	1.69	2.32
39	0.98	1.56	2.13
40	0.89	1.40	1.92
41	0.78	1.24	1.70
42	0.67	1.06	1.45

From Mari G, Deter RL. Middle cerebral artery flow velocity waveforms in normal and small-for-gestational-age fetuses. Am J Obstet Gynecol 1992;166:1262-1270.
*PI = −1.9763 + (0.32737 GA) + (−0.00611 GA²).
†Predicted value − (2 × 0.184 × Predicted value).
‡Predicted value + (2 × 0.184 × Predicted value).
GA, Gestational age.



Pulsatility index in the middle cerebral artery with gestation (mean, 95th and 5th centiles).

FETAL VENOUS DOPPLER

Doppler wave form from the central venous circulation reflect the right ventricle physiological status. They are obtained from the ductus venosus and inferior vena cava. IVC can be imaged from a central plane of the chest and abdomen. IVC Doppler wave form are obtained from two locations. Inlet in to the right atrium entrance and segment between the hepatic veins and the ductus venosus.

Transverse view of the fetal abdomen at abdominal circumference is used to obtain the ductus venosus waveform. Ductus venosus can be identified as it branches from the portal vein. IVC has triphasic wave forms.[10] The first phase corresponds to the ventricular systole. The second phase corresponds to early diastole and the third phase to late diastole and the atrial kick.

DOPPLER CHANGES IN IUGR

This is characterized by a decreased MCA pulsatility index and an increased UA Pulsatility Index. This changes suggest increased vascular resistance of the UA and cerebral vasodilation. When comparing Doppler indices in the MCA in fetuses appropriate for gestational age (AGA) and growth restricted fetuses at the same gestational age, the IUGR fetuses will have a lower PI value at the MCA than the AGA fetuses. It means that in IUGR fetuses, MCA has a lower vascular resistance than in AGA fetuses. This is associated with an increased blood flow to the brain.

Failure to get a low resistant circulation in MCA is associated with a subsequent risk of pregnancy adverse outcome.

UTERINE ARTERY:

In IUGR the failure of normal endovascular trophoblastic invasion of the spiral arteries results in increased uterine artery vascular resistance and decreased perfusion of the placenta. [21, 22]

The abnormal uterine circulation is characterized by

The presence of a notch(small notch at the beginning of diastole) in the wave form and an increase in impedance index after 22 weeks of gestation [23]

Failure of end diastolic flow to increase throughout pregnancy.[23]

Abnormal patterns include

- persistence of notching throughout pregnancy
- persistence of a high resistance flow throughout pregnancy
- reversal of diastolic flow throughout pregnancy: severe state

In the second trimester, an abnormal PI and uterine artery notching best predicts the preeclampsia. In high-risk patients an increased RI is the best predictor of IUGR.

Abnormal uterine circulation is associated with increased risk of complication. The complications include preeclampsia, preterm delivery fetal growth retardation, non releasing fetal status in utero

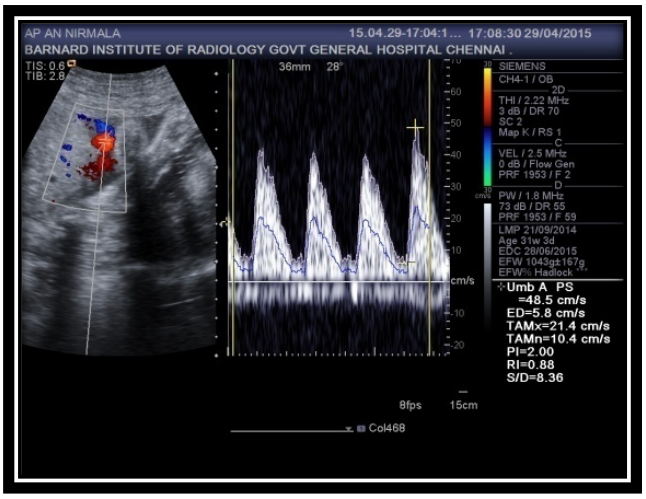
UMBLICAL ARTERY

In pathologic conditions such as IUGR are associated with an increased placental vascular resistance.[4] The UA waveforms change in these conditions, usually with a decreased diastolic component.[26-30]

Factors affecting Doppler waves

1. The fetal breathing affects the umbilical artery waveforms. (should be obtained during periods of fetal apnea.

2. A fetal cardiac arrhythmia particularly periods of bradycardia



Doppler image showing reduced diastolic flow in a IUGR baby.

In milder form of placental insufficienc, some fetuses have a decreased diastolic velocity . This remains constant with advancing gestation and never becomes absent or reversed.

As the placental insufficiency worsens, it then becomes absent, and later the umbilical artery diastolic flow is reversed.[5] The umbilical artery blood velocity waveform usually changes in a progressive manner as below

- reduction in end diastolic flow: increasing RI values, PI values and S:D ratios
- absent end diastolic flow (AEDF): RI = 1
- reversal of end diastolic flow (REDF)

Absent or reversed end diastolic flow is commonly associated with severe IUGR(9), and oligohydromnios.

MIDDLE CEREBRAL ARTERY

In IUGR, there is increased blood flow to the fetal brain. This effect is termed the brain-sparing effect. There is increase in blood flow during diastole, demonstrated by Doppler ultrasound of the MCA.

In growth restricted fetuses, the presence of reversed MCA flow or the disappearance of the brain-sparing effect is a critical event for the

fetus.[32-35] The brain-sparing effect is also demonstrated by a lower value of the MCA PI.[8] The MCA PI changes with increasing gestational age. The brain sparing effect may be transient. This brain sparing effect may be lost in the overstressed human fetus.

FACTORS ASSOCIATED WITH LOW MCA PULSATILITY INDEX:

LOW MCA PI

Post uterine contractions

Brain growth spurt

Hypoxemia and acidemia

High fetal heart rate

Severe anemia

Ductal constriction and tricuspid insufficiency

Post-transfusion

Therapeutic amniocentesis

FACTORS ASSOCIATED WITH HIGH MCA PULSATILITY INDEX

Fetal head compression

Uterine contractions

Oligohydramnios

Low fetal heart rate

Sustained hypoxemia with academia

MCA PSV

In IUGR fetuses, MCA PSV progressively increases with advancing gestation in all fetuses. and it trends toward normalization before fetal death or delivery .

Conversely, the MCA it subsequently tends to decrease slightly just before fetal demise or fetal biophysical deterioration. Despite the reduction in MCA PSV it's value remains above the upper limit of normal until a few hours before delivery or fetal demise.

RECENT STAGING GUIDELINES FOR IUGR FETUSES

It is based on fetal biometry, Doppler ultrasound cardiovascular changes, amniotic fluid, and clinical parameters.

"STAGE I

Abnormal umbilical artery pulsatility index (UA PI)

Abnormal middle cerebral artery pulsatility index (MCA PI)

STAGE II

Umbilical artery absent/reversed flow (UA ARF)

Elevated middle cerebral artery peak systolic velocity (MCA PSV)

Abnormal ductus venosus pulsatility index (DV PI)*

Umbilical vein pulsation

Absent ductus venosus is included in stage II

STAGE III

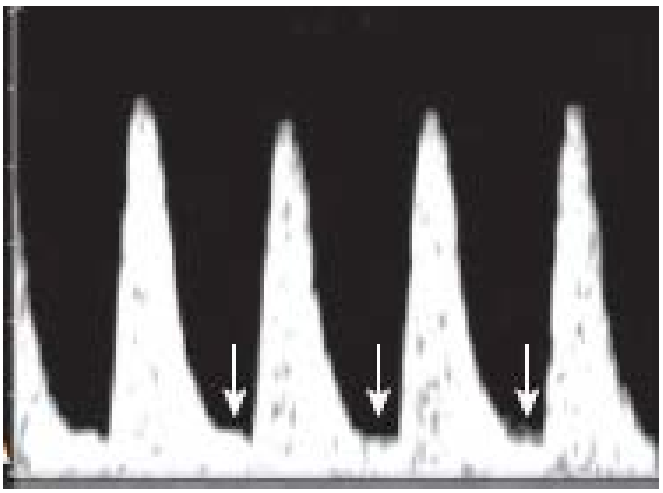
Ductus venosus reversed flow

Umbilical vein reversed flow

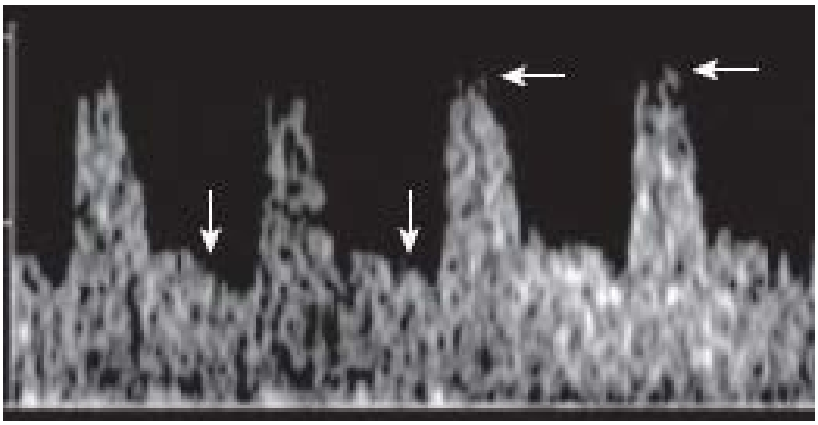
Tricuspid valve (TV) E/A ratio >1)

Tricuspid Valve Regurgitation (TR)".

Stage I IUGR: abnormal waveforms

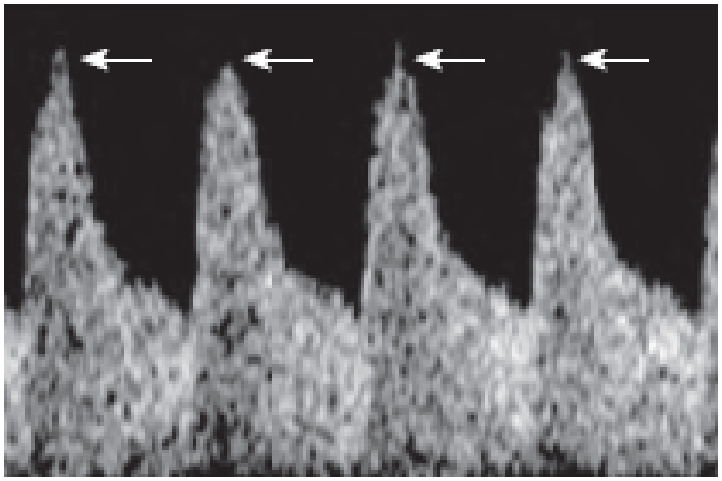


Abnormal umbilical artery (UA)- Low diastole

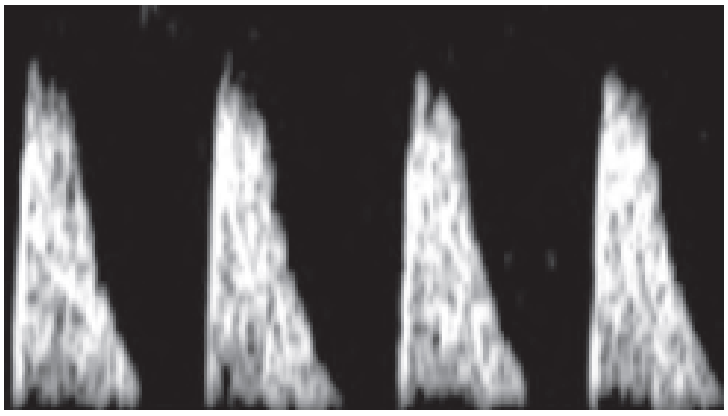


Abnormal middle cerebral artery Increased Diastole, Normal PSV.

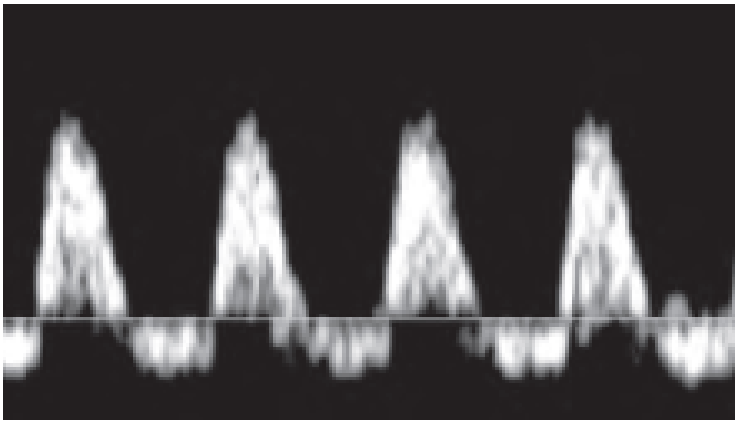
STAGE II



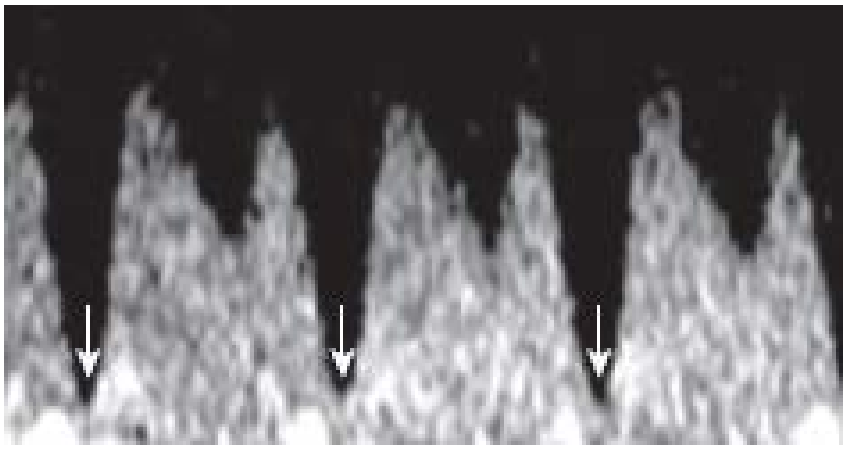
Elevated middle cerebral artery-peak systolic velocity (PSV) (27 weeks)



Umbilical artery absent diastolic flow

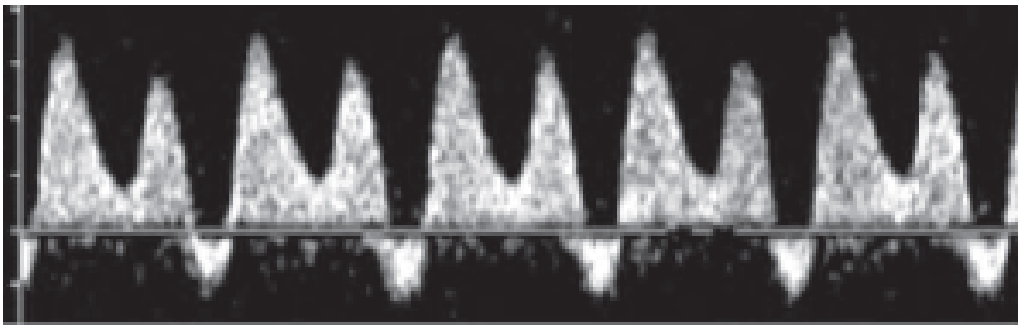


Umbilical artery reversed flow

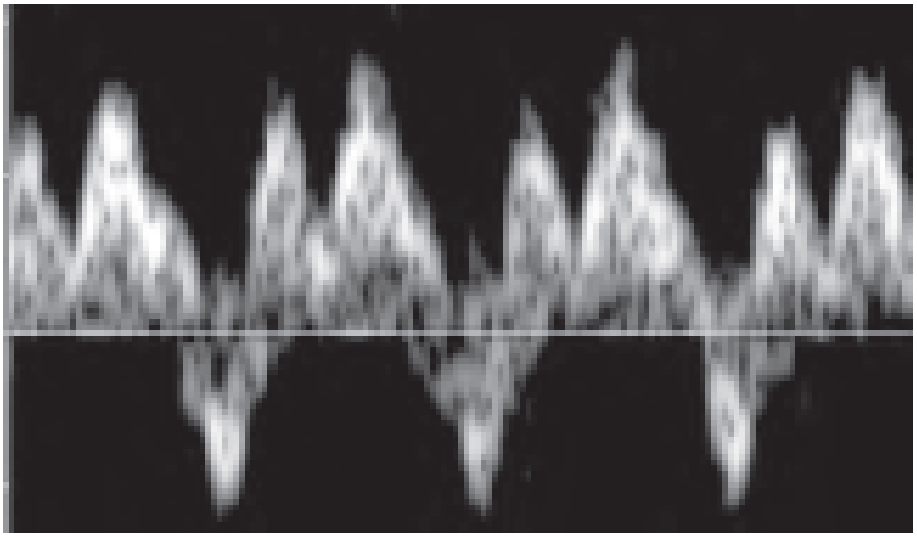


Abnormal ductus venosus Doppler sonogram with low “a” wave.

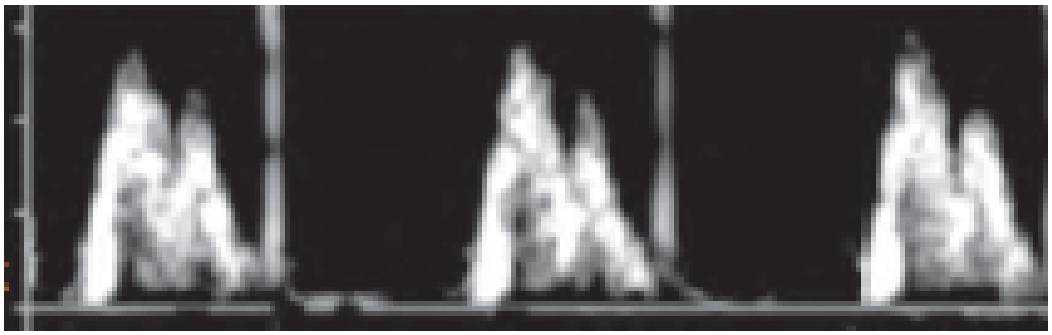
Stage III IUGR: abnormal waveforms.



Ductus venosus - reversed flow.



Umbilical vein - reversed flow



Abnormal tricuspid valve waveform .

Major advantage for selecting the parameters included,

1. The ability to track the progression of abnormal parameters that start at the UA and MCA

2. If the fetus remains undelivered ,Later it can be extended into other parameters, up to fetal demise

3. Another advantage is the simplicity of the system. (Only one cardiac valve and four fetal vessels).

MANAGEMENT

“Stage I IUGR - Mild IUGR,

Usually these patients are managed as outpatients.

Stage II IUGR

These patients are admitted for observation.

They are delivered earlier

The mortality in stage II IUGR fetuses is intermediate between the other two stages.

Stage III IUGR

These patients are at high risk for fetal demise.

They have a low birth weight than both stage II and stage I

Stage III IUGR fetuses are delivered earlier

The mortality for stage III fetuses are high".

DOPPLER OF OTHER ARTERIES

In AGA fetuses and in those with IUGR, many other arteries have been examined. Assessment of these arteries increases the understanding of fetal physiology and pathophysiology in these conditions, though the study of these vessel adds no new information to the study of the UA and MCA in the management of IUGR fetuses.

Descending Aorta

The fetal descending aorta Waveforms are usually studied at the level of the diaphragm.[15] The Waveforms are different distal to the origin of the renal arteries.[30, 31]

VENOUS SYSTEM

IVC

Triphasic pulsatile pattern is noted in IVC before its entrance into the right atrium [12]. To depict the inferior vena The best ultrasound plane cava is a longitudinal or coronal one, where it runs anterior to the descending aorta and to the right of and nearly parallel to it.

In IUGR fetuses, reversed flow is seen during atrial contraction[13]. This increase in reversed flow is attributed to an abnormal ventricular chamber,wall compliance and abnormal ventricular filling characteristics.

DUCTUS VENOSUS

In a mid-sagittal longitudinal section of the fetal trunk, the ductus venosus can be visualized in its full length.

The biphasic waveform is noted in DV. It is characterized by two peaks: the “S”, or peak systolic velocity (PSV), which corresponds to the highest velocity of the blood in systole and and the “D”, which corresponds to the rapid filling of the ventricles.

In normal AGA fetuses, there is forward flow at the DV. The PI for veins decreases with advancing gestation. In growth-restricted fetuses, the PI increases in the DV. In the most severe cases, there is A wave of reversed flow.

AIM OF OUR STUDY

To evaluate the usefulness of

- Pulsatility index (PI) of the umbilical artery (UA)
- Pulsatility index (PI) fetal middle cerebral artery (MCA)
- Ratio of the MCA PI to the UA PI (C/U ratio)

in the diagnosis of small-for gestational- age (SGA) fetuses and in the prediction of adverse perinatal outcome.

MATERIALS AND METHODS

STUDY AREA

- Barnard Institute of Radiology,
- Madras Medical College, Chennai.

STUDY PERIOD - 6 months

STUDY DESIGN - Prospective observational

INCLUSION CRITERIA:

- Clinically diagnosed case of IUGR(based on decrease or no increase in abdominal girth / fundal height and Insufficient weight gain,)
- LMP(Last menstrual period) of the patient well known.
- Gestational age of patient between 31 and 41 weeks.
- Singleton pregnancy;

- live fetus with no sign of chromosomal abnormality
- Clinical diagnosis of placental insufficiency
- Birth at the institution.

EXCLUSION CRITERIA:

- Cases in which a congenital anomaly is detected in the newborn,
- Cases of fetal anemia,
- Cases in which the fetal Doppler examination is not possible up to 7 days before birth.

METHODOLOGY

The study population

- The study population comprised pregnancies of 30-41 weeks' gestation that had been diagnosed clinically as IUGR and referred for USG colour doppler.
- The control population comprised pregnancies of 30-41 weeks' gestation referred for routine antenatal ultrasound Doppler Study.
- The UA PI, RI and the MCA PI , RI as well as the C/U ratio, RI ratio were calculated.
- All the patients were subjected to a repeat USG colour doppler examination after 15 days, when the findings of the initial study were reconfirmed .

FOLLOW UP :

- The pregnancies were followed-up and the final perinatal outcome of each case was noted.

- They are followed up for the mode of delivery, weeks of delivery, birth weight of baby, need for neonatal resuscitation, NICU care.

DATA ANALYSIS :

Statistical package were chequed at periodical intervals and at the end of the study

ANALYSIS PLAN :

For each group, the fetal biometry and weight were calculated. In experimental group the small for gestational age was confirmed. And in the control group, the adequate for gestational age was confirmed.

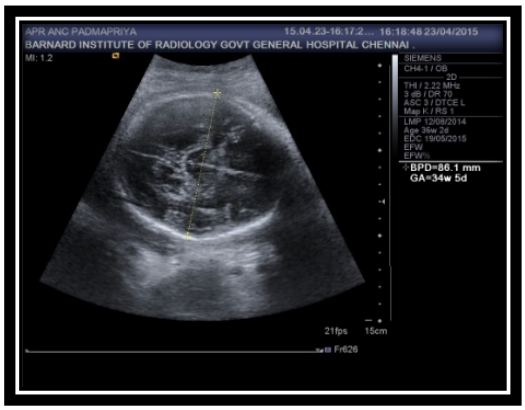
The uterine artery, umbilical artery and middle cerebral artery Doppler parameters were studied. SD ratio, PI values, RI values, PI Ratios, RI Ratios of Umbilical artery, MCA were recorded.

The umbilical pulsatility and resistive indices values >95^{th} percentile were considered abnormal. For the cerebral indices the values <5^{th} percentile was considered abnormal. The reference values were taken from standard charts.

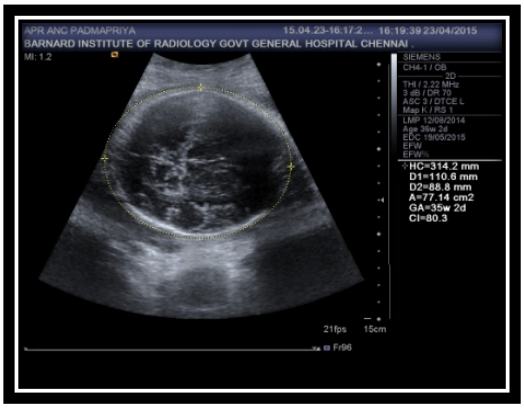
CASE 1

23 YEAR OLD PRIMI CASE LMP: 12.8.14 EDD: 19.5.15

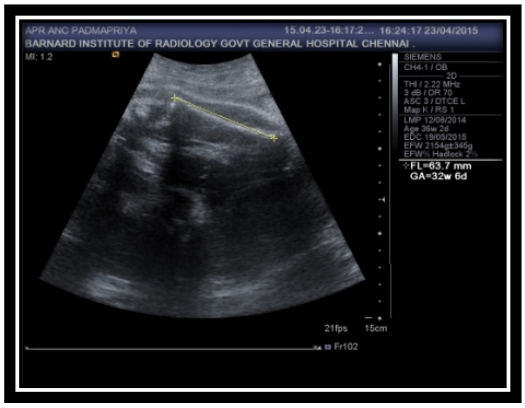
BIPARIETAL DIAMETER



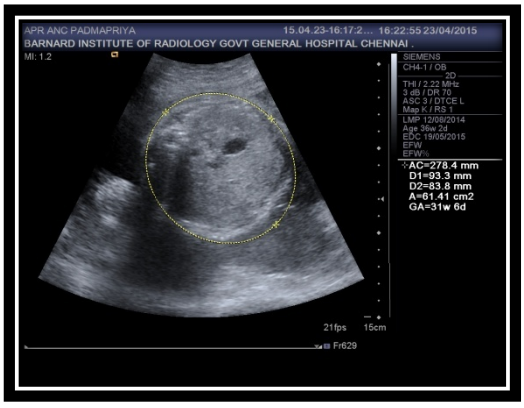
HEAD CIRCUMFERENCE



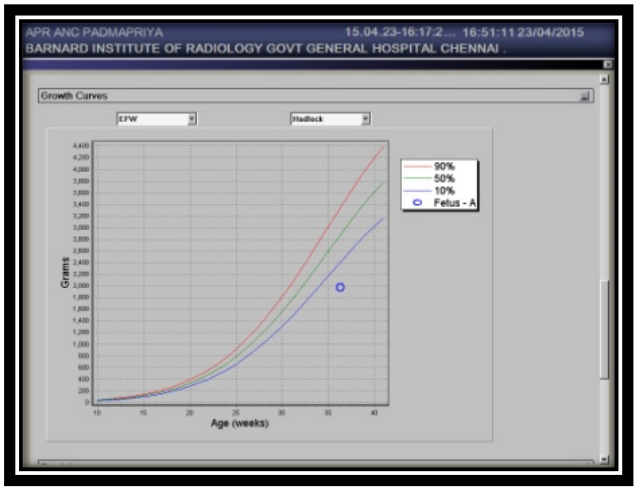
FEMUR LENGTH



ABD CIRCUMFERENCE



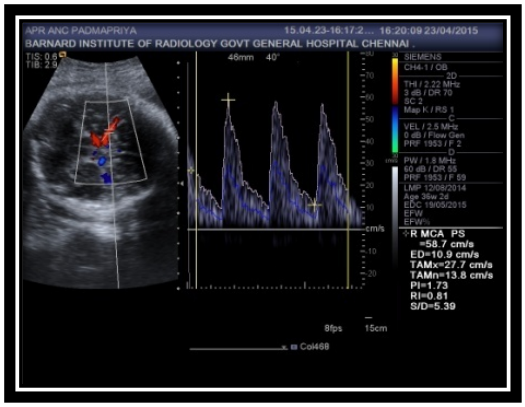
GROWTH CHART



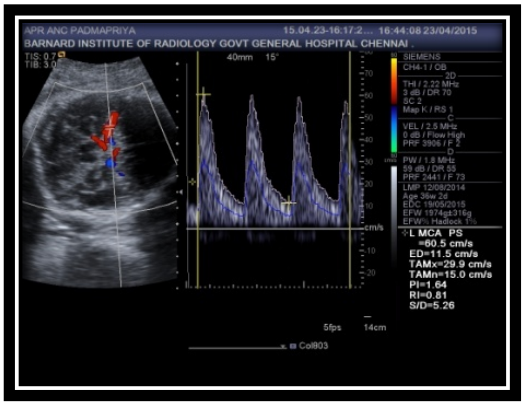
The fetal biomemtry shows growth parameters < 10 th percentile for the age of the fetus. This is indicative of IUGR.

DOPPLER STUDY

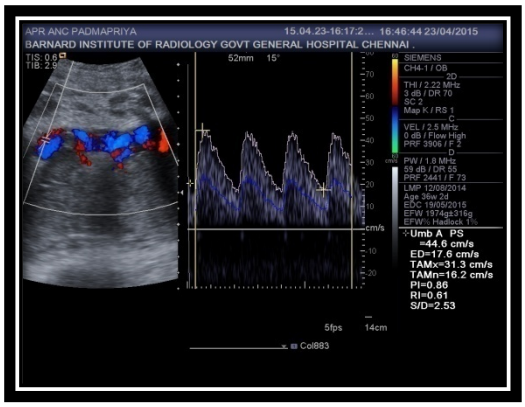
RIGHT MCA



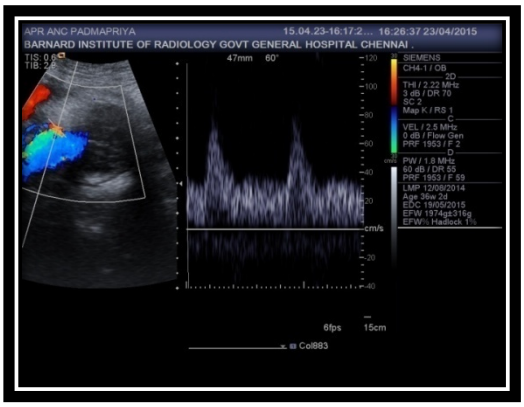
LEFT MCA



UMBILICAL ARTERY



UTERINE ARTERY – NOTCH



Doppler study of the same fetus shows uterine notch and normal ri ratios, PI ratios.

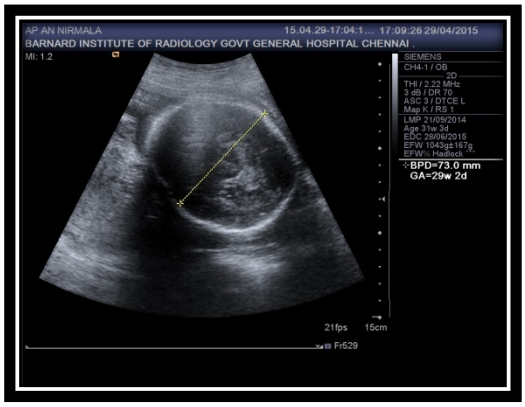
IMPRESSION: A CASE OF IUGR WITH NORMAL DOPPLER .

FOLLOW UP: LSCS was done after 37 completed weeks for fetal distress . Newborn baby developed fetal distress and required NICU admission for 5 days.

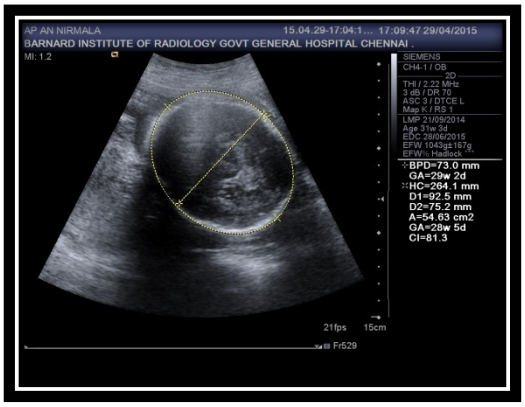
CASE2

25 year FEMALE ANC CASE LMP :21.9.14 EDD : 28.6.15

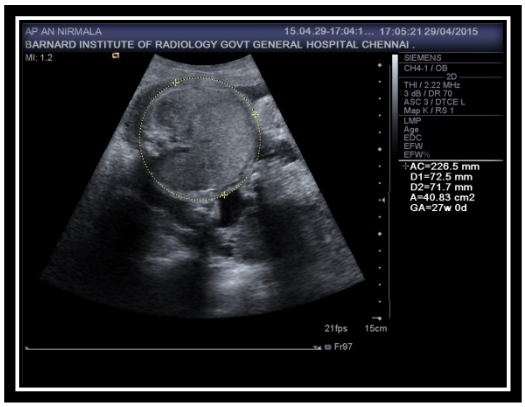
BIPARIETAL DIAMETER



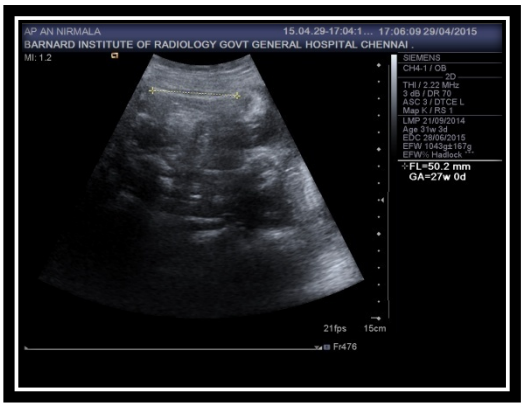
HEAD CIRCUMFERENCE



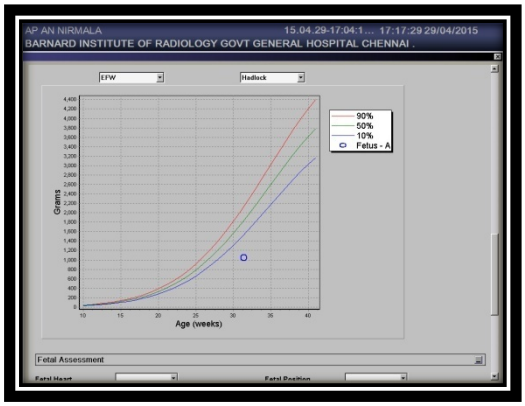
ABD CIRCUMFERENCE



FEMORAL LENGTH



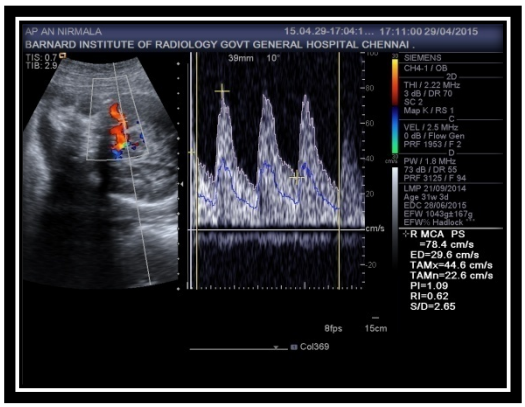
GROWTH CHART



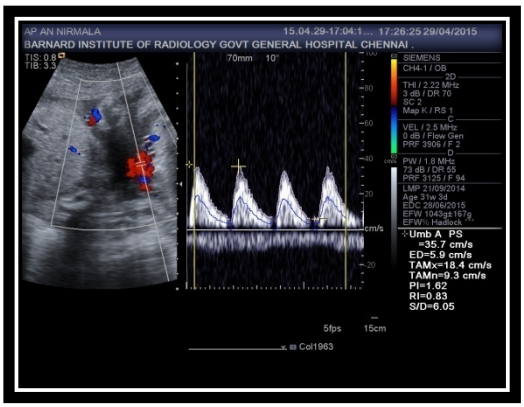
The fetal biomemtry shows growth parameters < 10 th percentile for the age of the fetus. This is indicative of IUGR.

DOPPLER STUDY

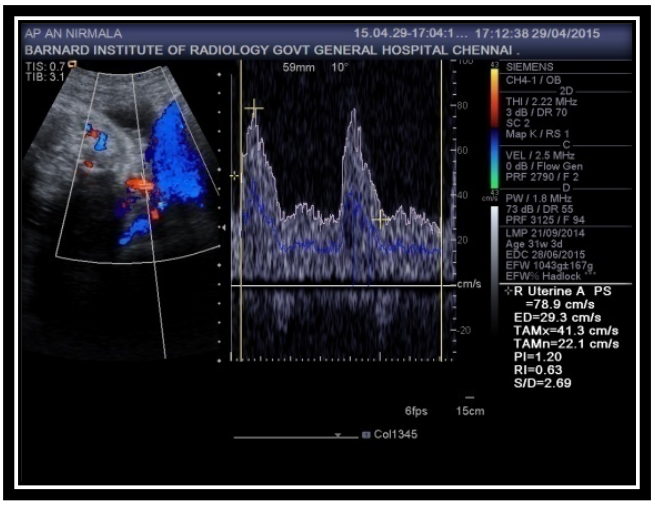
RIGHT MCA



UMBILICAL ARTERY



RIGHT UTERINE ARTERY



Doppler shows uterine notch and abnormal PI ratio and RI ratio.

This patient antenatal case was sonographically diagnosed as IUGR. Doppler study shows uterine notch and abnormal Doppler studies.

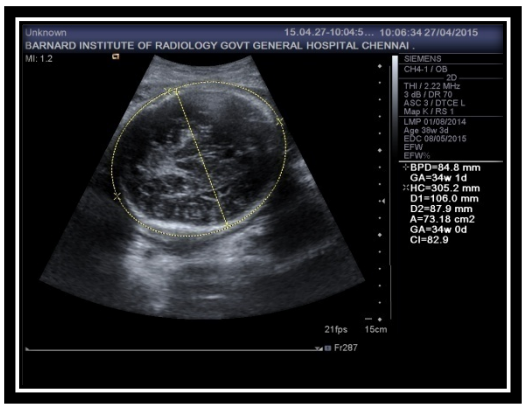
FOLLOW UP:

LSCS was done on the next day of Doppler studies for oligohydromnios. Newborn baby needed NICU care for 5 days for observation.

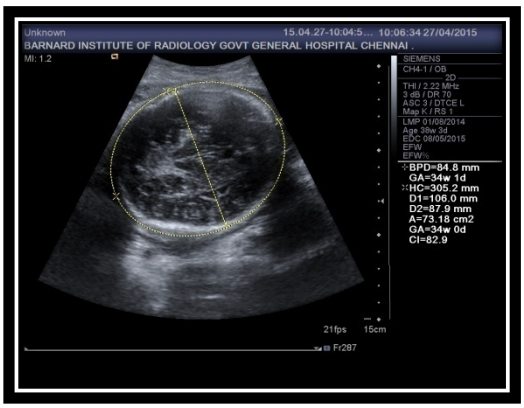
CASE- 3

29 year FEMALE ANC CASE LMP : 1.8.14 EDD : 8.5.15

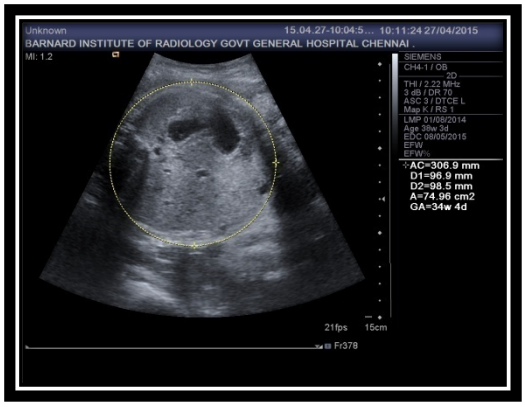
BIPARIETAL DIAMETER



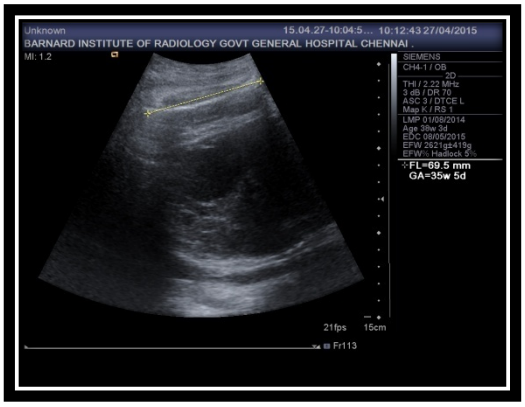
HEAD CIRCUMFERENCE



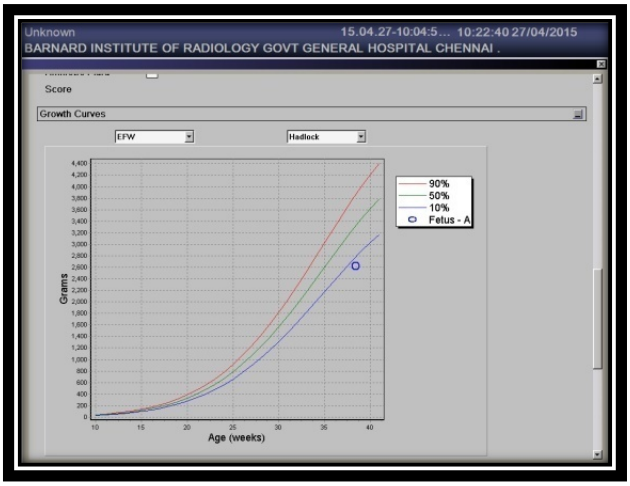
ABD CIRCUMFERENCE



FEMUR LENGTH



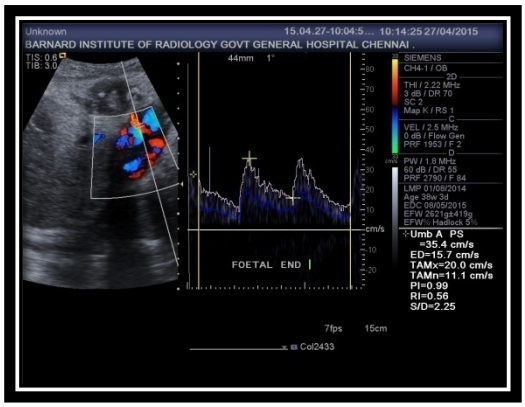
GROWTH CHART

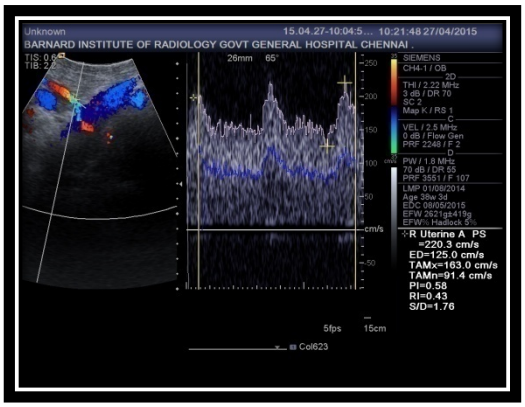


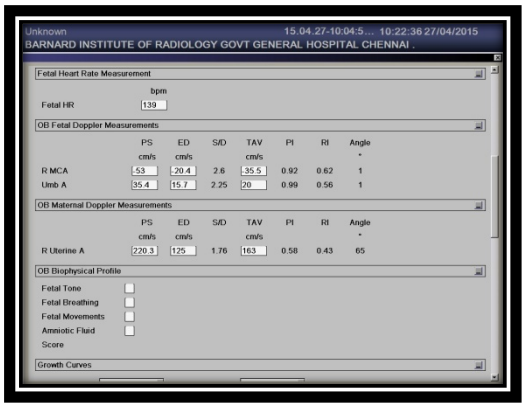
The fetal biomemtry shows growth parameters < 10 th percentile for the age of the fetus. This is indicative of IUGR.

DOPPLER STUDY

UMBILICAL ARTERY **UTERINE ARTERY- NOTCH**







IMPRESSION

A case of IUGR with Reversal PI - ratio with normal RI ratio. Uterine artery doppler shows uterine notch.

FOLLOW UP

Baby delivered by LSCS for fetal respiratory distress. Baby New Born required NICU Care for 10 days. New Born developed respiratory distress and intra ventricular hemorrhage.

STATISTICAL ANALYSIS

Modalities used :

1) The collected data was analysed with with SPSS 16.0 version. To describe about the data descriptive statistics frequency analysis, percentage analysis were used for categorical variables and for continuous variables the mean and S.D were used. To find the significance difference between the bivariate samples in the Independent groups (Experimental & Controls) Unpaired t-test was used.

2) Receiver operating characteristic (ROC) curves were drawn to find out area under the curve (AUC) for differentiation of two groups and cut-off value was calculated so as to achieve the highest average sensitivity and specificity. To find the significance in the categorical data Chi-Square test was test. In all the above statistical tools the probability value 0.05 is considered as significant level.

P – Value	Highly Significant at P ≤ .01
P – Value	Significant at P ≤ .05
P –Value	No Significant at P ≥ .05

Totally, 67 ante natal cases referred as intrauterine growth retardation were taken for study as experimental group. They were diagnosed clinically as intrauterine growth retardation. During follow up after 2 weeks, the interval growth was normal for 20 persons. So they

were excluded from the study. 5 antenatal cases were excluded because of associated fetal anomaly. We could not follow up 12 cases. So they were excluded from the study. Finally 30 cases were included as experimental group . 30 cases referred for routine ante natal ultrasound were selected as control.

The experimental cases were followed up after 2 weeks and were assessed. The diagnosis of intrauterine growth retardation was confirmed The patients were followed up till delivery for the adverse perinatal events .

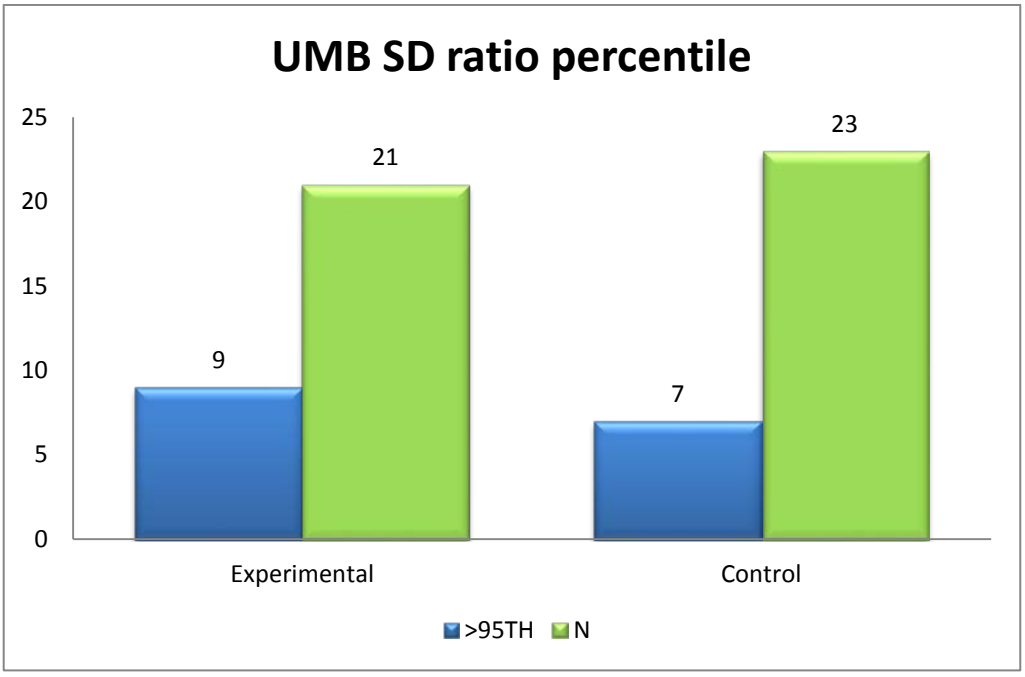
The perinatal events considered as adverse include small for gestational age, LSCS for fetal indication, Fetal / neonatal distress, NICU care, intra ventricular hemorrhage, fetal death.

OBSERVATION :

UMBILICAL SD RATIO

Umbilical SD ratio was done. The reference values taken from "American journal of obstetrics and gynaecology 192-933" was used to categorise SD ratio for gestational age as Normal and above 95 th centile.

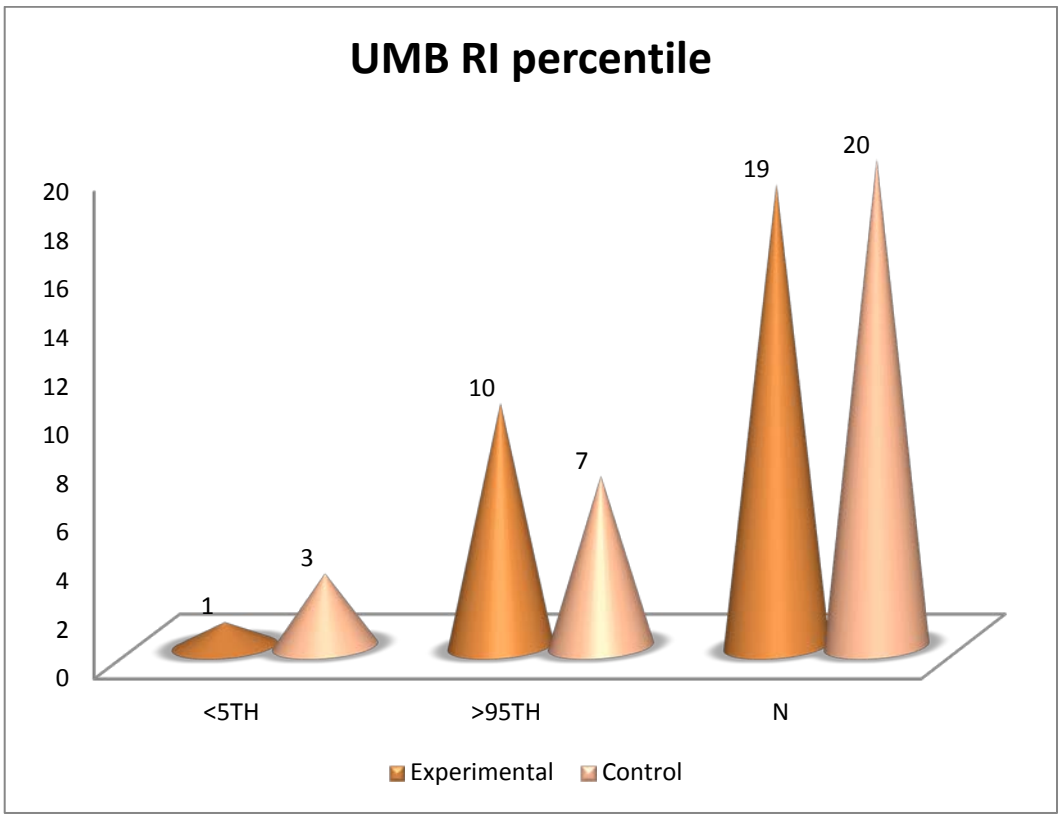
Among the experimental group 21cases have normal SD Ratio and 9 persons have SD ratio above 95thcentile. In control group, 23cases have normal SD Ratio and 7 persons have SD ratio above 95thcentile.



	Experimental	Control
>95TH	9	7
N	21	23

UMBILICAL RI PERCENTILE:

Umbilical RI was done. The reference values were taken from "Ultrasound in obstetrics and gynecology". Among the experimental group 10 persons have RI above 95thcentile and 19cases have normal RI. In control group, 7 persons have RI above 95thcentile and 20cases have normal RI.

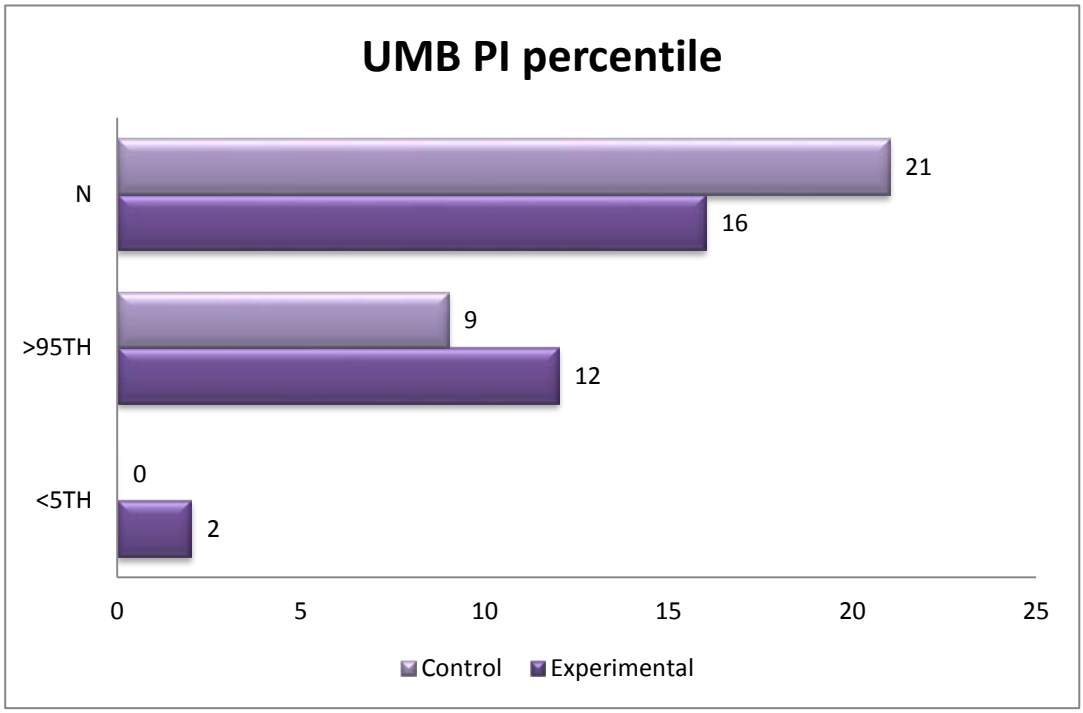


	Experimental	Control
<5TH	1	3
>95TH	10	7
N	19	20

UMBILICAL PI PERCENTILE:

Umbilical PI was done. The reference values were taken from "ultrasound in obstetrics and gynecology volume 1 Staugart Newyork – 2005".

Among the experimental group 12 persons have PI above 95thcentile and 16cases have normal PI. In control group, 9 persons have PI above 95thcentile and 21cases have normal PI.

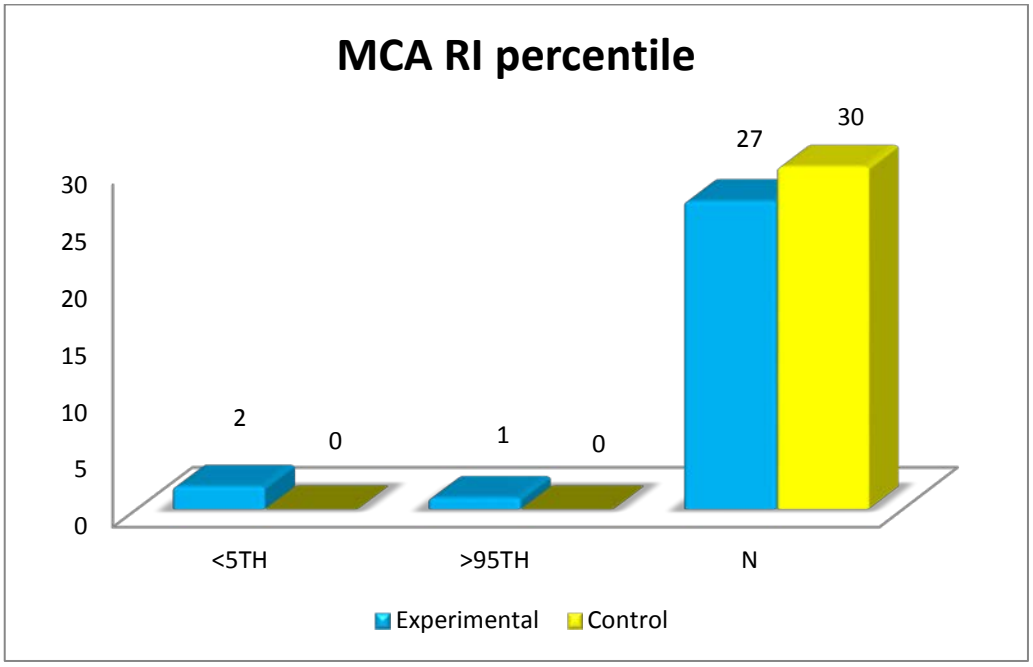


	Experimental	Control
<5TH	2	0
>95TH	12	9
N	16	21

MIDDLE CEREBRAL ARTERY RI PERCENTILE:

Middle cerebral artery RI was done. The reference values were taken from “Ultrasound in obstetrics and gynecology volume 1 Staugart Newyork – 2005”.

Among the experimental group 2 persons have RI below 5thcentile and 27 cases have normal RI. In control group, no persons have RI below 5thcentile and 30 cases have normal RI.

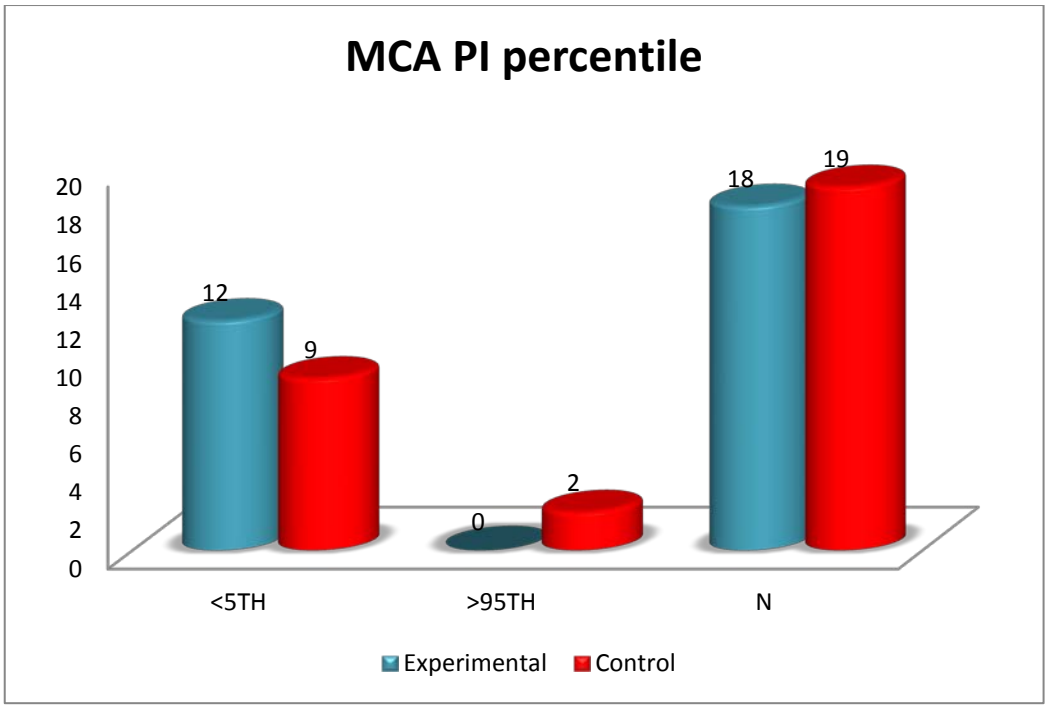


	Experimental	Control
<5TH	2	0
>95TH	1	0
N	27	30

MIDDLE CEREBRAL ARTERY PI PERCENTILE:

Middle cerebral artery PI was done. The reference values were taken from “Ultrasound in obstetrics and gynecology volume 1 Staugart Newyork – 2005”.

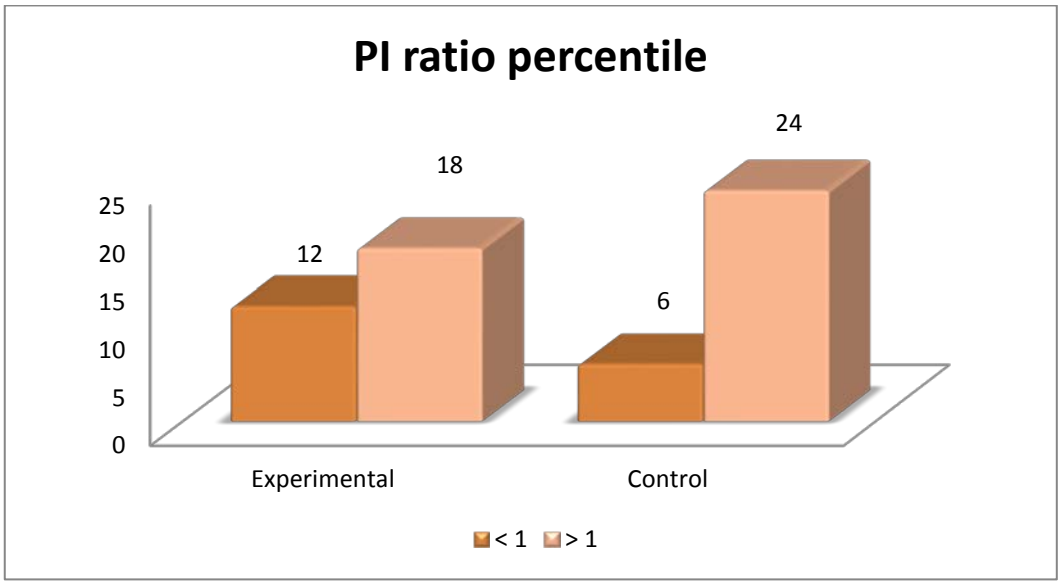
Among the experimental group 12 persons have PI below 5thcentile and 18 cases have normal PI. In control group, 9 persons have PI below 5thcentile and 19 cases have normal RI.



	Experimental	Control
$<5^{TH}$	12	9
>95TH	0	2
N	18	19

PI RATIO:

The ante natal cases with intra uterine growth retardation showing PI ratio <1 include 12 and >1 include 18 cases. In control group, PI ratio <1 include 6 persons and PI ratio >1 include 24 cases.

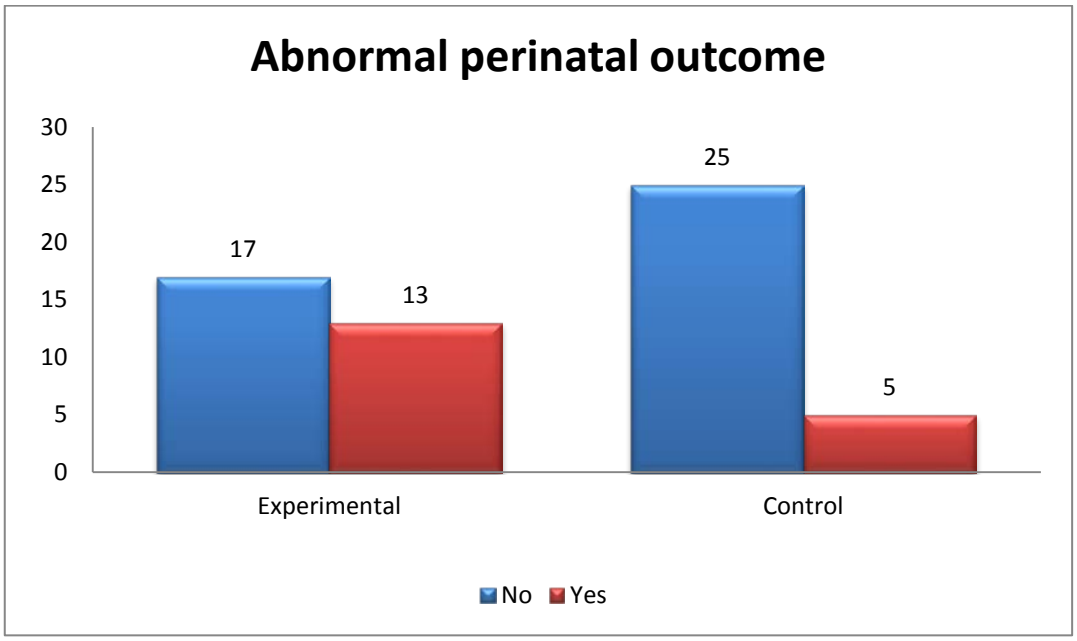


	Experimental	Control
< 1	12	6
> 1	18	24

FOLLOW UP PERINATAL OUTCOME

Perinatal outcome studied includes preterm delivery, small for gestational age, NICU care, respiratory distress, intra cranial hemorrhage and lower section cesaerean section .

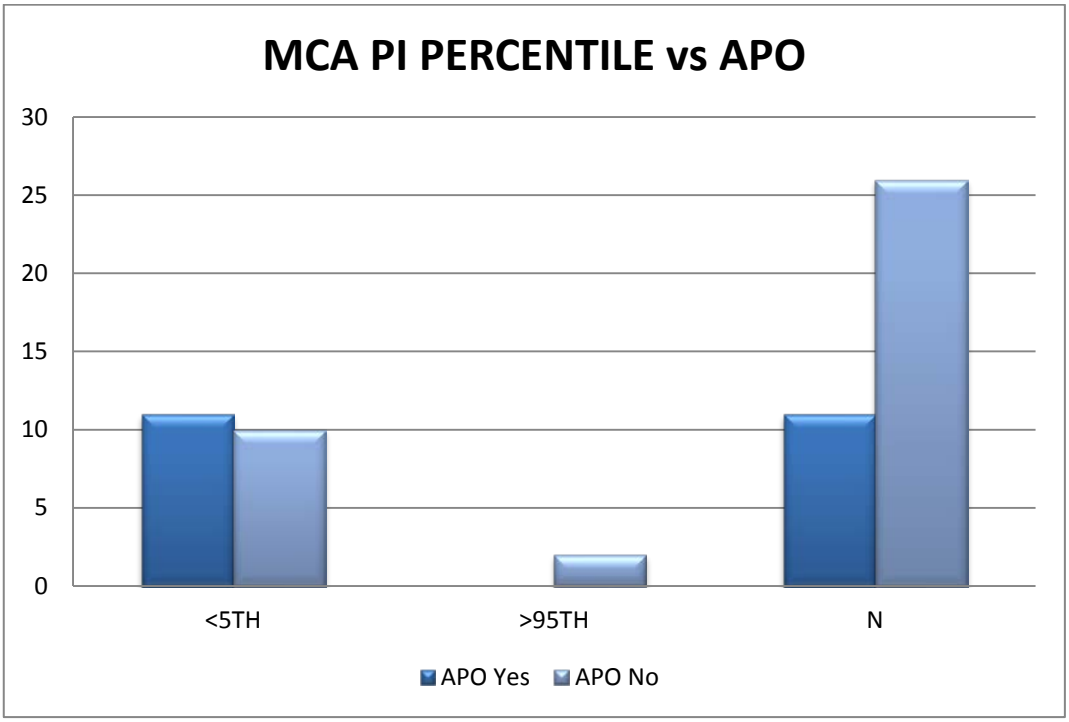
Total number of cases with abnormal perinatal outcome in experimental group include 17 cases and in control group include 5 cases.



	Experimental	Control
No	17	25
Yes	13	5

MCA PERCENTILE VS APO

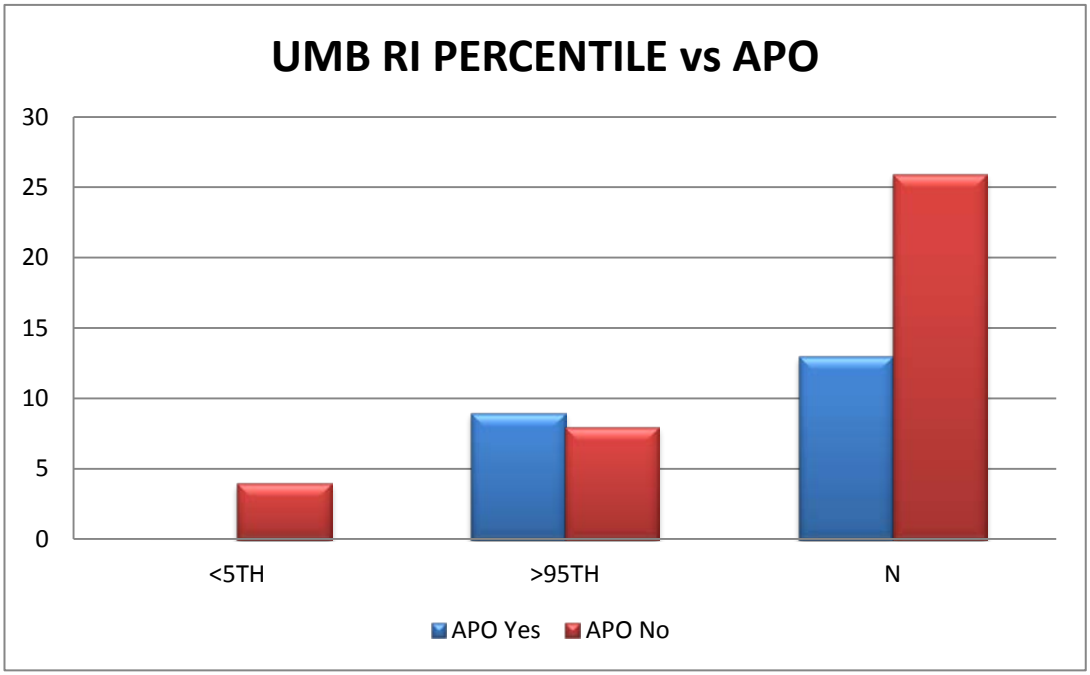
In comparing MCA PI percentile and abnormal perinatal outcome , 11 persons with MCA PI <5th centile have abnormal perinatal outcome and 11 cases with normal PI percentile have abnormal perinatal outcome. 10 cases with MCA PI <5th centile have normal perinatal outcome.



	APO	
	Yes	**No**
<5TH	11	10
>95TH	0	2
N	11	26

UMBILICAL RI PERCENTILE VS APO

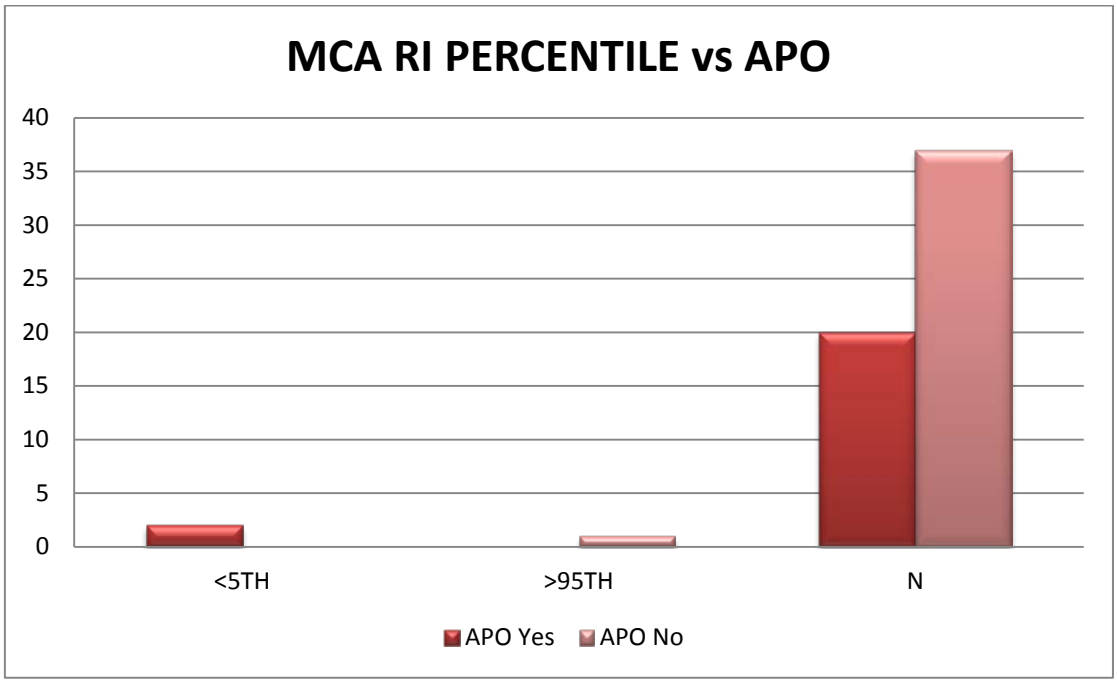
In comparing umbilical RI percentile and abnormal perinatal outcome , 9 persons with umbilical RI >95th centile have abnormal perinatal outcome and 13 cases with normal RI percentile have abnormal perinatal outcome. 8 cases with umbilical RI >95th centile have normal perinatal outcome.



	APO	
	Yes	**No**
<5TH	0	4
>95TH	9	8
N	13	26

MIDDLE CEREBRAL ARTERY RI PERCENTILE VS APO

In comparing middle cerebral artery RI percentile and abnormal perinatal outcome , 2 persons with middle cerebral artery RI <5th centile have abnormal perinatal outcome and 20 cases with normal RI percentile have abnormal perinatal outcome.



	APO	
	Yes	**No**
<5TH	2	0
>95TH	0	1
N	20	37

UMBILICAL SD RATIO * EXPERIMENT AND CONTROL GROUP

Comparison is done with umbilical SD ratio to identify the association between experimental and control group. The comparison shows SD ratio of > 95th percentile in 30% of experimental group and 23% of control group.

The P – value is 0.559 which indicates no significant association between experimental and control group.

Crosstab

			EC		
			Experimental	Control	Total
UMB SD RATIO PERCENTILE	>95TH	Count	9	7	16
		% within EC	30.0%	23.3%	26.7%
	N	Count	21	23	44
		% within EC	70.0%	76.7%	73.3%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.341[a]	1	.559		
Continuity Correction[b]	.085	1	.770		
Likelihood Ratio	.342	1	.559		
Fisher's Exact Test				.771	.386
N of Valid Cases	60				

MCA RI PERCENTILE * EXPERIMENTAL CONTROL GROUP

Comparision is done with MCA RI percentile to identify the association between experimental and control group. The comparition shows RI of < 5th percentile in 6.7% of experimental group and 0% of control group.

The P – value is 0.206 which indicates no significant association between experimental and control group.

Crosstab

			EC		
			Experimental	Control	Total
MCA RI PERCENTILE	<5TH	Count	2	0	2
		% within EC	6.7%	0.0%	3.3%
	>95TH	Count	1	0	1
		% within EC	3.3%	0.0%	1.7%
	N	Count	27	30	57
		% within EC	90.0%	100.0%	95.0%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.158[a]	2	.206
Likelihood Ratio	4.317	2	.116
N of Valid Cases	60		

a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .50.

UMBILICAL RI PERCENTILE - EXPERIMENTAL CONTROL GROUP

Comparision is done with UMB RI percentile to identify the association between experimental and control group. The comparison shows RI of >95th percentile in 33.3% of experimental group and 23.3% of control group.

The P – value is 0.460 which indicates no significant association between experimental and control group.

Crosstab

			EC		
			Experimental	Control	Total
UMB RI PERCENTILE	<5TH	Count	1	3	4
		% within EC	3.3%	10.0%	6.7%
	>95TH	Count	10	7	17
		% within EC	33.3%	23.3%	28.3%
	N	Count	19	20	39
		% within EC	63.3%	66.7%	65.0%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.555[a]	2	.460
Likelihood Ratio	1.604	2	.448
N of Valid Cases	60		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.00.

MCA PI PERCENTILE - EXPERIMENTAL CONTROL GROUP

Comparision is done with UMB PI percentile to identify the association between experimental and control group. The comparison shows PI of < 5th percentile in 40% of experimental group and 30% of control group.

The P – value is 0.293 which indicates no significant association between experimental and control group.

MCA PI PERCENTILE - EC

Crosstab

			EC		
			Experimental	Control	Total
MCA PI PERCENTILE	<5TH	Count	12	9	21
		% within EC	40.0%	30.0%	35.0%
	>95TH	Count	0	2	2
		% within EC	0.0%	6.7%	3.3%
	N	Count	18	19	37
		% within EC	60.0%	63.3%	61.7%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.456[a]	2	.293
Likelihood Ratio	3.230	2	.199
N of Valid Cases	60		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.00.

UMBILICAL PI PERCENTILE - EXPERIMENTAL CONTROL GROUP

Comparision is done with UMB PI percentile to identify the association between experimental and control group. The comparison shows PI of >95th percentile in 40% of experimental group and 30% of control group.

The p – value is 0.212 which indicates no significant association between experimental and control group

Crosstab

			EC		
			Experimental	Control	Total
UMB PI PERCENTILE	<5TH	Count	2	0	2
		% within EC	6.7%	0.0%	3.3%
	>95TH	Count	12	9	21
		% within EC	40.0%	30.0%	35.0%
	N	Count	16	21	37
		% within EC	53.3%	70.0%	61.7%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.104[a]	2	.212
Likelihood Ratio	3.880	2	.144
N of Valid Cases	60		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.00.

PI RATIO - EXPERIMENTAL CONTROL GROUP

Comparision is done with PI Ratio to identify the association between experimental and control group. The comparison shows PI ratio of <1 in 40% of experimental group and 20% of control group.

The p – value is 0.91 which indicates no significant association between experimental and control group

Crosstab

			EC		
			Experimental	Control	Total
PI RATIO PERCENTILE	< 1	Count	12	6	18
		% within EC	40.0%	20.0%	30.0%
	> 1	Count	18	24	42
		% within EC	60.0%	80.0%	70.0%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.857[a]	1	.091		
Continuity Correction[b]	1.984	1	.159		
Likelihood Ratio	2.899	1	.089		
Fisher's Exact Test				.158	.079
N of Valid Cases	60				

ABNORMAL PERINATAL OUTCOME * EXPERIMENTAL CONTROL GROUP

Comparision is done with abnormal perinatal outcome to identify the association between experimental and control group. The comparison shows abnormal perinatal outcome in 56.7% of experimental group and 16.7% of control group.

The P – value is 0.001which indicates significant association between experimental and control group

Crosstab

			EC		
			Experimental	Control	Total
APO	Yes	Count	17	5	22
		% within EC	56.7%	16.7%	36.7%
	No	Count	13	25	38
		% within EC	43.3%	83.3%	63.3%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.335[a]	1	.001		
Continuity Correction[b]	8.684	1	.003		
Likelihood Ratio	10.771	1	.001		
Fisher's Exact Test				.003	.001
Linear-by-Linear Association	10.163	1	.001		
N of Valid Cases	60				

LSCS * EC

Comparision is done with LSCS to identify the association between experimental and control group. The comparison shows LSCS in 73% of experimental group and 43% of control group.

The P – value is 0.037which indicates significant association between experimental and control group

Crosstab

			EC		
			Experimental	Control	Total
LSCS	No	Count	9	17	26
		% within EC	30.0%	56.7%	43.3%
	Yes	Count	21	13	34
		% within EC	70.0%	43.3%	56.7%
Total		Count	30	30	60
		% within EC	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.344[a]	1	.037		
Continuity Correction[b]	3.326	1	.068		
Likelihood Ratio	4.402	1	.036		
Fisher's Exact Test				.067	.034
N of Valid Cases	60				

MCA PI PERCENTILE* ABNORMAL PERINATAL OUTCOME

Comparision is done with MCA PI percentile andabnormal perinatal outcome to identify the association between these two.

The comparison shows that 50% of cases with abnormal perinatal outcome are associated with MCA PI percentile <5th percentile group . 68.4% cases with normal MCA PI percentile are associated with normal perinatal outcome.

The P – value is 0.125which indicates no significant association between experimental and control group

Crosstab

			APO		
			Yes	No	Total
MCA PI PERCENTILE	<5TH	Count	11	10	21
		% within APO	50.0%	26.3%	35.0%
	>95TH	Count	0	2	2
		% within APO	0.0%	5.3%	3.3%
	N	Count	11	26	37
		% within APO	50.0%	68.4%	61.7%
Total		Count	22	38	60
		% within APO	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.158[a]	2	.125
Likelihood Ratio	4.761	2	.092
N of Valid Cases	60		

UMBILICAL RI PERCENTILE* ABNORMAL PERINATAL OUTCOME

Comparision is done with umbilical RI percentile and abnormal perinatal outcome to identify the association between these two. The comparson shows that 40.9% of cases with abnormal perinatal outcome are associated with umbilical PI percentile >95th percentile group . 59.1% of cases with abnormal perinatal outcome are associated with normal umbilical PI percentile .

The P – value is 0.109 which indicates no significant association between experimental and control group

UMB RI PERCENTILE -APO

Crosstab

			APO		
			Yes	No	Total
UMB RI PERCENTILE	<5TH	Count	0	4	4
		% within APO	0.0%	10.5%	6.7%
	>95TH	Count	9	8	17
		% within APO	40.9%	21.1%	28.3%
	N	Count	13	26	39
		% within APO	59.1%	68.4%	65.0%
Total		Count	22	38	60
		% within APO	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.441[a]	2	.109
Likelihood Ratio	5.703	2	.058
N of Valid Cases	60		

MCA RI PERCENTILE* ABNORMAL PERINATAL OUTCOME

Comparision is done with MCA RI percentile and abnormal perinatal outcome to identify the association between these two. The comparison shows that 9.1 % of cases with abnormal perinatal outcome are associated with MCA RI percentile <5th percentile group 90.9% of cases with abnormal perinatal outcome are associated with normal MCA RI percentile .

The P – value is 0.129 which indicates no significant association between experimental and control group

MCA RI PERCENTILE - APO

Crosstab

			APO		
			Yes	No	Total
MCA RI PERCENTILE	<5TH	Count	2	0	2
		% within APO	9.1%	0.0%	3.3%
	>95TH	Count	0	1	1
		% within APO	0.0%	2.6%	1.7%
	N	Count	20	37	57
		% within APO	90.9%	97.4%	95.0%
Total		Count	22	38	60
		% within APO	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.095[a]	2	.129
Likelihood Ratio	4.988	2	.083
N of Valid Cases	60		

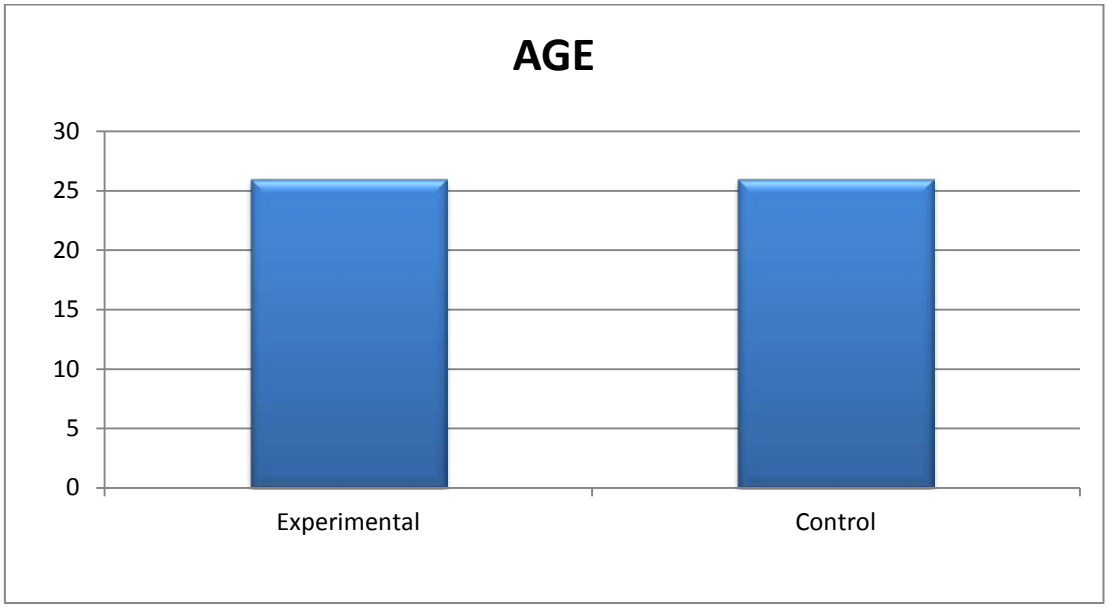
T-TEST

To Find The Significance Difference Between The Bivariate Samples In The Independent Groups (Experimental & Controls) Unpaired T-Test Was Used

Group Statistics

EC		N	Mean	Std. Deviation	Std. Error Mean
AGE	Experimental	30	25.50	3.998	.730
	Control	30	25.63	4.004	.731
MCA SD RATIO	Experimental	30	4.3083	1.55929	.28469
	Control	30	6.0967	2.64295	.48253
MCA PI	Experimental	30	1.4243	.37869	.06914
	Control	30	1.7803	.60464	.11039
	Control	30	1.8290	.81947	.14961
RI RATIO	Experimental	30	1.0963	.24339	.04444
	Control	30	1.2390	.23851	.04355

AGE DISTRIBUTION

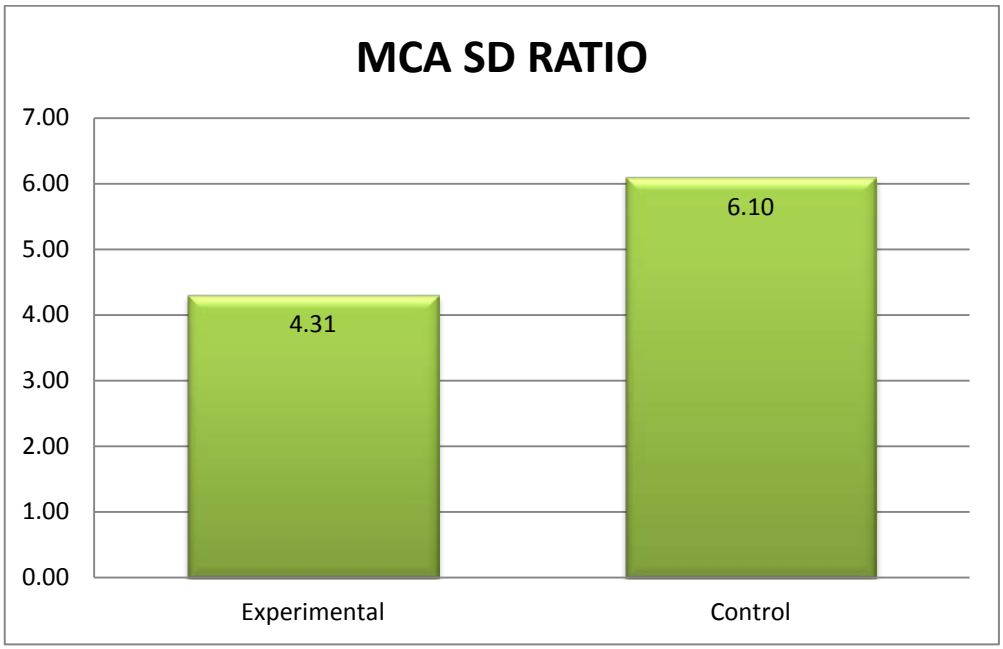


	AGE
Experimental	26
Control	26

Comparing the mean age of experimental group and control group shows no significant difference between these two groups. This indicates that the samples age distribution is unbiosed.

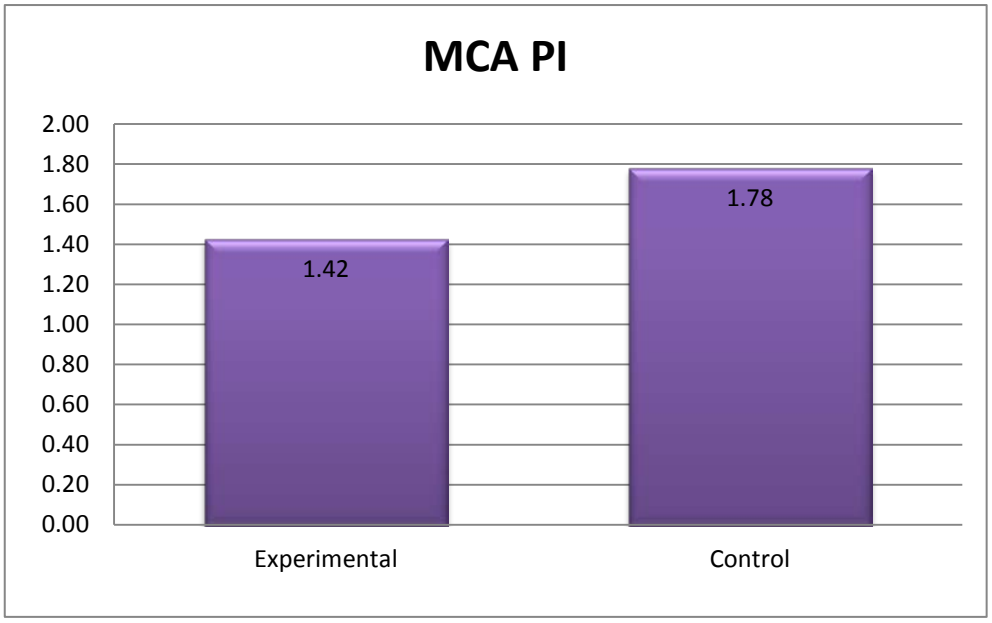
MCA SD RATIO

MCA SD ratio mean in experimental group is 4.31 and MCA SD ratio mean in control group is 6.1. Standard deviation in experimental group is 1.5 and MCA SD ratio mean in control group is 2.6.



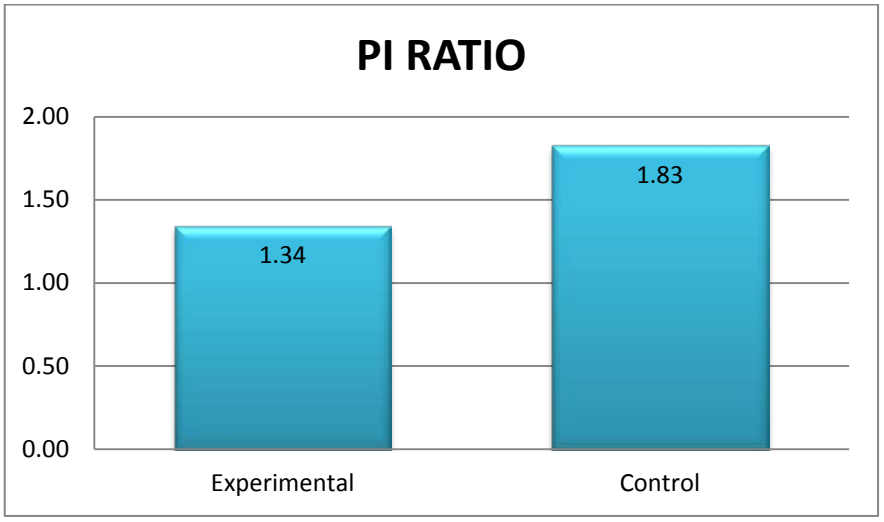
MCA PI

MCA PI mean in experimental group is 1.42 and MCA PI mean in control group is 1.78. Standard deviation in experimental group is 0.37 and MCA SD ratio mean in control group is 0.60 .



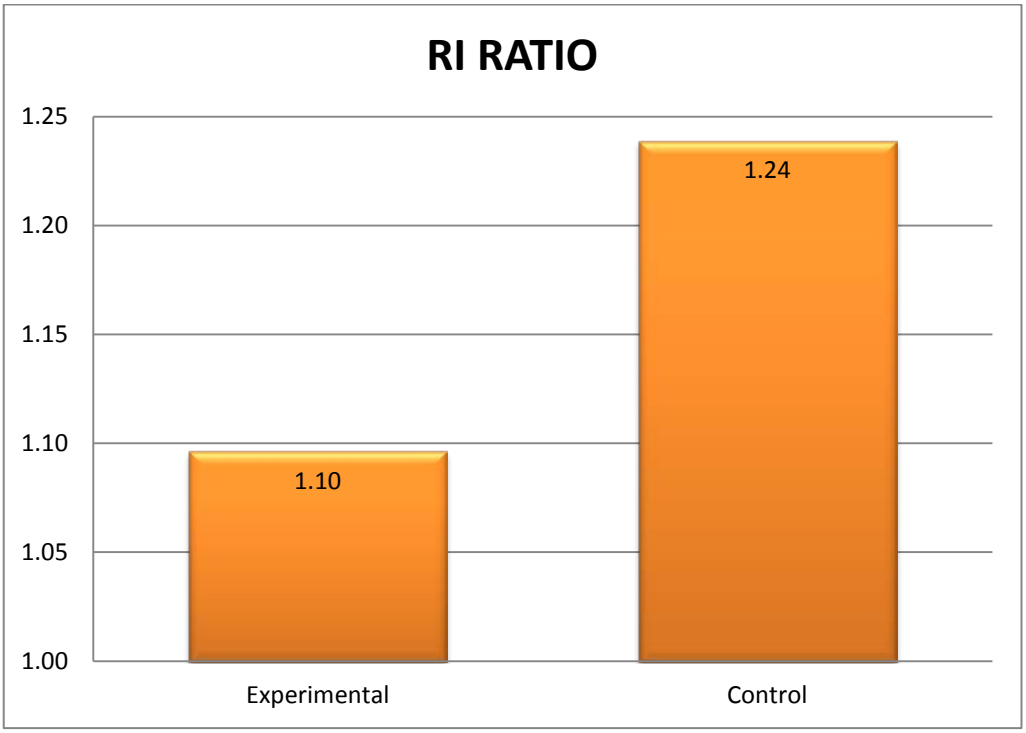
PI RATIO

PI RATIO mean in experimental group is 1.34 and MCA PI mean in control group is 1.83 . Standard deviation in experimental group is 0.5 and MCA SD ratio mean in control group is 0.81 .



RI RATIO

RI RATIO mean in experimental group is 1.1 and mean in control group is 1.24 . Standard deviation in experimental group is 0.24 and MCA SD ratio mean in control group is 0.23.



INDEPENDENT SAMPLES TEST

Shows no significant difference in age distribution between experimental and control cases.

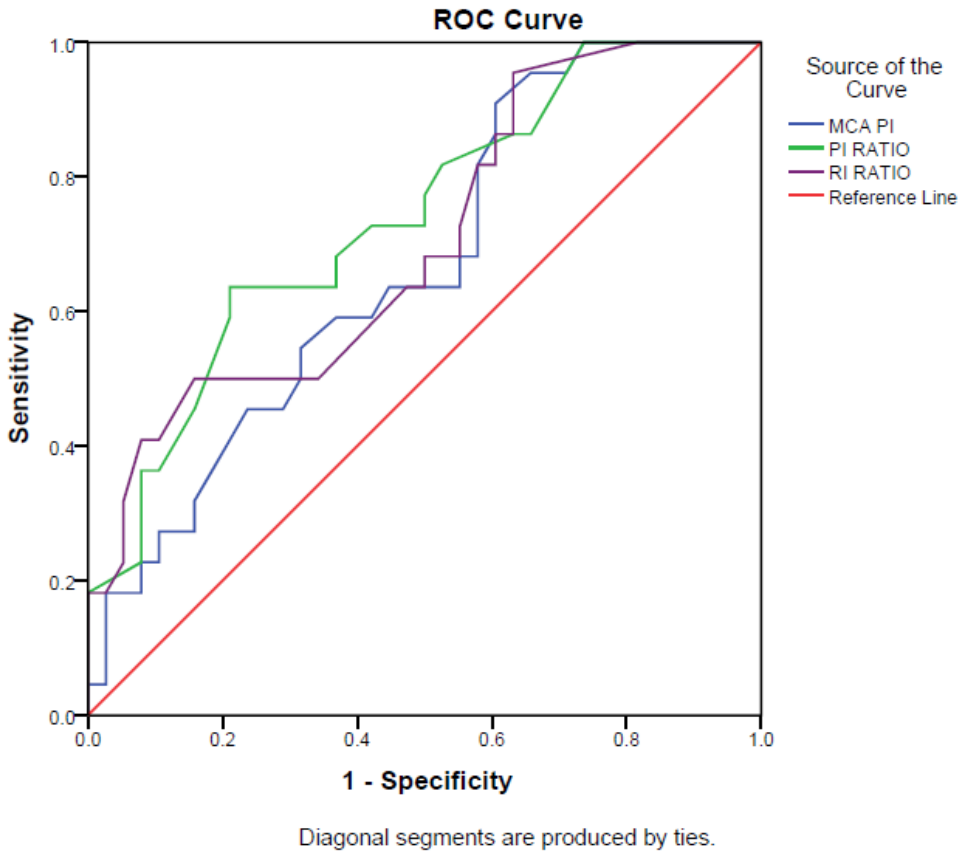
There is significant difference in MCA SD Ratio (P value - 0 . 002) between experimental and control group.

There is also significant difference in MCA PI (P value - 0 . 008), PI ratio (P value - 0 . 008) and RI ratio (P value - 0 . 025) between experimental and control group

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
AGE	Equal variances assumed	.000	.983	-.129	58	.898	-.133	1.033	-2.201	1.935
	Equal variances not assumed			-.129	58.000	.898	-.133	1.033	-2.201	1.935
MCA SD RATIO	Equal variances assumed	1.755	.190	-3.192	58	.002	-1.78833	.56025	-2.90980	-.66686
	Equal variances not assumed			-3.192	47.007	.003	-1.78833	.56025	-2.91542	-.66125
MCA PI	Equal variances assumed	2.592	.113	-2.733	58	.008	-.35600	.13026	-.61673	-.09527
	Equal variances not assumed			-2.733	48.717	.009	-.35600	.13026	-.61780	-.09420
PI RATIO	Equal variances assumed	4.356	.041	-2.727	58	.008	-.48600	.17821	-.84272	-.12928
	Equal variances not assumed			-2.727	49.663	.009	-.48600	.17821	-.84400	-.12800
RI RATIO	Equal variances assumed	.368	.546	-2.293	58	.025	-.14267	.06222	-.26720	-.01813
	Equal variances not assumed			-2.293	57.976	.025	-.14267	.06222	-.26721	-.01813

ROC CURVE

Receiver operator characteristics (ROC) - to determine the cut off ratio or threshold relative value of different parameters which had the maximum sensitivity and specificity



The cut – off value for MCA PI is 1.515 .

PI ratio is 1.425.

RI Ratio is 1.125

Case Processing Summary

APO	Valid N (listwise)
Positive[a]	22
Negative	38

Smaller values of the test result variable(s) indicate stronger evidence for a positive actual state.

a. The positive actual state is Yes.

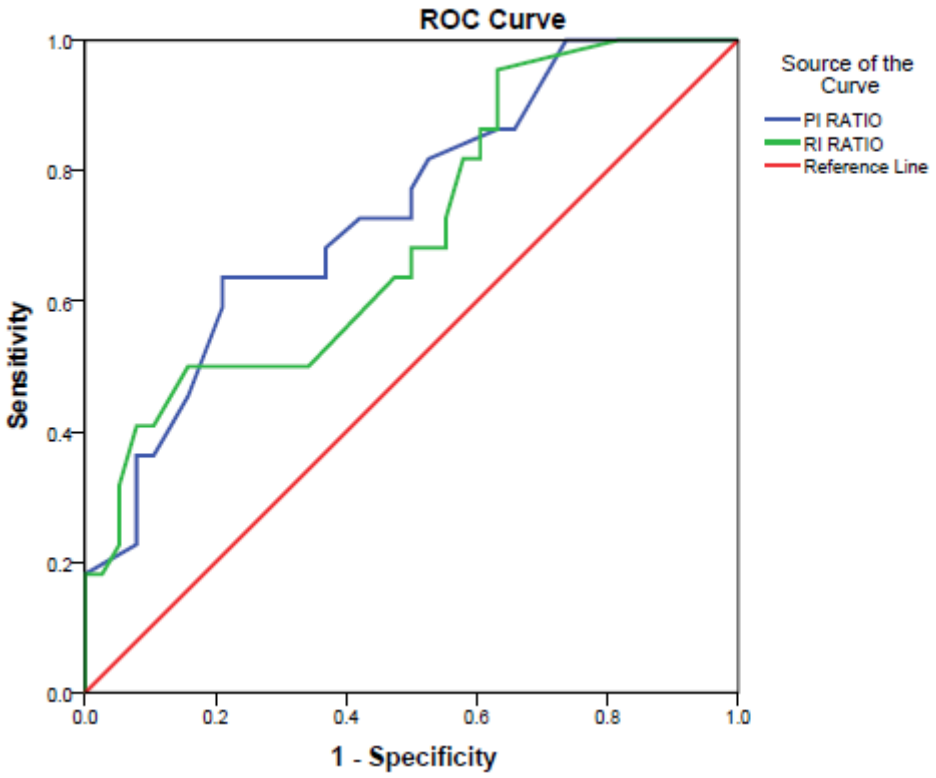
Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MCA PI	.670	.070	.029	.533	.808
PI RATIO	.739	.066	.002	.610	.868
RI RATIO	.703	.070	.009	.566	.839

N-60	NO OF FINDING								
	TP	FN	FP	TN	Sensitivity	Specificity	PPV	NPV	DA
					%	%	%	%	%
MCA PI	13	9	16	22	59	57.9	44.8	80.9	58
PI RATIO	14	9	14	24	60.9	63.1	50	82.7	62
RI RATIO	14	8	18	20	63.6	52.6	43.7	81.4	58.3

The area under the curve is 0.670 for MCA PI , 0.739 for PI ratio, 0.703 for RI ratio. The highest area under the curve is seen for PI ratio. P value for PI ratio is 0. 002 , MCA PI is 0.029 and RI ratio is 0.009. PI Ratio shows more statistical significance.

PI RATIO * RI RATIO CROSSTABULATION



PI RATIO * RI RATIO Cross tabulation

Count

		RI RATIO		Total
		+ ve	- ve	
PI RATIO	+ ve	22	6	28
	- ve	10	22	32
Total		32	28	60

ACCURACY = 73.66 %

RESULTS:

Totally the sample includes 60 antenatal cases. 30 cases are in experimental group. 30 cases are in control group. The mean age in both group is 26 years which indicates un - biased age distribution. All experimental cases show < 10^{th} centile for gestational age which were calculated based on the Last Menstual Period. One patient's Last Menstual Period (LMP) was not known. In all experimental group, the diagnosis of IUGR was confirmed by follow up USG scan after 2 weeks.

2 experimental cases (2 /30) are associated with abnormal MCA RI (<5^{th} percentile) Both cases are delivered by LSCS and associated with abnormal perinatal morbidity.

9 experimental cases (9 / 30) are associated with abnormal UMB RI (>95^{th} percentile) . 7 Cases are delivered by LSCS and 6 cases are associated with abnormal perinatal morbidity.

11 experimental cases (11/30) are associated with abnormal MCA PI (<5^{th} percentile) 7 cases are delivered by LSCS and 8 Cases are associated with abnormal perinatal morbidity.

11 experimental cases (11/30) are associated with abnormal UMB PI (>95^{th} percentile) . 10 Cases are delivered by LSCS and 8 cases are associated with abnormal perinatal morbidity.

8 experimental cases (8/30) are associated with abnormal RI ratio. 7 Cases are delivered by LSCS and 7 cases are associated with abnormal perinatal morbidity.

11experimental cases (11/30) are associated with abnormal PI ratio. All cases were delivered by LSCS and were associated with abnormal perinatal morbidity.

There is statistically significant difference in MCA SD Ratio (p - 0. 002, MCA PI (P - 0 . 008), PI Ratio (P - 0 . 008) and RI Ratio (p - 0 . 025).

This indicates that there is significant change in these doppler values in IUGR babies compared to normal ante natal cases.

N-60	NO OF FINDING								
	TP	FN	FP	TN	Sensitivity	Specificity	PPV	NPV	DA
					%	%	%	%	%
MCA PI	13	9	16	22	59	57.9	44.8	80.9	58
PI RATIO	14	9	14	24	60.9	63.1	50	82.7	62
RI RATIO	14	8	18	20	63.6	52.6	43.7	81.4	58.3

Area Under the Curve

Test Result Variable(s)	Area	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
MCA PI	.670	.029	.533	.808
PI RATIO	.739	.002	.610	.868
RI RATIO	.703	.009	.566	.839

ROC curve indicates that the sensitivity is more for RI ratio. The specificity positive predictive value, negative predictive value are higher for PI ratio. The cut off value is 1.425 for PI Ratio with accuracy of 62%. The cut-off value for RI ratio is accuracy of 58.3%.

ROC curve between RI RATIO and PI RATIO shows sensitivity of PI ratio to predict the perinatal outcome more than the RI Ratio is 69%. The specificity is 78.5% more than the RI Ratio. The positive predictive value is 44.8% and negative predictive value is 88.7% more than the RI ratio. The accuracy is 73.6% more than the RI ratio.

N-60	**NO OF FINDING**								
	TP	**FN**	**FP**	**TN**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**DA**
					%	%	%	%	%
PI RATIO	22	10	6	22	69	78.5	78.8	88.7	73.6

This statistical analysis of the parameters confirms that the PI Ratio is better than the RI ratio in predicting the abnormal perinatal outcome. The PI Ratio cut – off values obtained in this study is 1.45. This study also confirms that RI ratio and MCA PI shows significant changes in the IUGR cases.

DISCUSSION

Small for gestational age fetuses are heterogenous group of fetuses with various causes. The causes include genetic factors and Intra uterine growth restriction. Various Doppler changes are noted in IUGR. This includes redistribution of blood to vital organs such as brain. This leads to changes in the Doppler parameters.

In our study abnormal Doppler parameter are seen in 6.7% in MCA RI (<5TH centile), 33% of cases in Umbilical RI(>95th percentile) , 40% of cases in MCA PI (<5TH centile), 40% of cases in Umbilical PI , 40% of cases in PI Ratios.50% of experimental cases show adverse perinatal outcome. 7 out of 30 cases needed NICU admission.

Various studies test the significance of changes in these parameters in diagnosis of IUGR and in prediction of adverse perinatal events so that the obstetrician can decide about the management.

Arduini and Rizzo et al (11) studied the characterestics of MCA, Umbilical artery, renal artery PI indices in prediction of adverse perinatal outcome. After the diagnosis of small for gestational age , the PI ratio was best test than PI indices of MCA, Umbilical artery, renal artery alone. The results in that study were sensitivity 89% , (vs 68%, 64%, 43%) specificity of 94% (91%, 88%, 91%) .

In another study chan et al studied 71 high risk cases . He followed up the cases with weekly umbilical artery, Middle cerebral artery Doppler until delivery. There was perinatal mortality and morbidity in 15% of cases. They found RI ratio is more sensitive than Umbilical atery SD Ratio, but less specific.

Dangolo Gramellini et al (1) studied cerebro umbilical ratio as a predictor of adverse perinatal . According to his study, sensitivity is higher in PI ratio and specificity and positive predictive value is higher in for MCA PI alone.

In our study, the sensitivity to predict the outcome is higher for RI Ratio, specificity is higher for PI Ratio. Positive predictive value, negative predictive values are also higher for PI ratio. Our study agree with Dangolo Gramellini et al study with high specificity of PI Ratio in predicting the adverse fetal outcome.

N-60	**NO OF FINDING**								
	TP	**FN**	**FP**	**TN**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**DA**
					%	**%**	**%**	**%**	**%**
MCA PI	13	9	16	22	59	57.9	44.8	80.9	58
PI RATIO	14	9	14	24	60.9	63.1	50	82.7	62
RI RATIO	14	8	18	20	63.6	52.6	43.7	81.4	58.3

Our study	**Sensitivity %**	**Specificity%**	**PPV**	**NPV**
MCA PI	59	57.9	44.8	80.9
PI RATIO	60.9	63.1	50	82.7
Grameti Et Al				
MCA PI	24	100	100	77.3
PI RATIO	68	98.4	94.4	88.0

Our study	**Sensitivity %**	**Specificity%**	**PPV**	**NPV**
MCA PI	59	57.9	44.8	80.9
PI RATIO	60.9	63.1	50	82.7
Katherine W				
MCA PI	91.7	53.9	15.1	98.6
PI RATIO	62.5	75.5	18.4	95.8

The cut- off value for PI Ratio Dangolo Gramellini et al is 1.08. The cut-off in our study is 1.45. The difference may be due to racial difference (Indian vs Western population) and small sample volume of our study .

CONCLUSION:

1. We performed systematic evaluation of all the doppler parameters values from the data acquired by Doppler study of 60 antenatal cases including 30 antenatal cases with intra uterine growth retarded fetuses. Delivery details and perinatal events were considered as end point.

2. Aim of our study was to evaluate the usefulness of Pulsatility index (PI) of the umbilical artery (UA) , Pulsatility index (PI) of fetal middle cerebral artery (MCA), Ratio of the MCA PI to the UA PI (C/U ratio) in the diagnosis of small-for gestational- age (SGA) fetuses and in the prediction of adverse perinatal outcome.

3. The MCA SD Ratio, MCAPI, PI Ratio shows significant role in the diagnosis of the Intra uterine growth retardation.

4. The PI Ratio is the better predictor of the adverse perinatal outcome than the RI Ratio, MCA PI index.

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ABBREVIATION:

IUGR	-	Intrauterine growth retardation;
UA	-	Umbilical artery ;
MCA	-	Middle cerebral artery;
PI	-	Pulsatility index;
RI	-	Resistive index;
PI Ratio	-	Pulsatility index ratio;
RI Ratio	-	Resistive index ratio;
SD	-	Systolic diastolic ratio;
APO	-	Abnormal perinatal outcome
LSCS	-	Lower segment caessarean section.
PSV	-	Peak Systolic velocity
EDV	-	End Diastolic Velocity
BPD	-	Biparietal diameter
SGA	-	Small for gestational Age
IVC	-	Inferior Venacava

PROFORMA

LMP EDD G P L Wt

Ht PH NO

OCCUPATION ADDRESS

PRESENTING COMPLAINT

PAST OBSTETRIC HISTORY

VITAL SIGNS Pulse BP RR

Hypertension diabetes medical illness BLOODTESTS

USG FINDINGS –PREVIOUS

EFW PERCENTILE

UMBLICAL ARTERY MCA

	SD	PI	RI
UMBILICAL ARTERY			
MCA			

Absent Diastole / End diastolic reversal

UTERINE ARTERY PI RI

DIASTOLIC NOTCH

C/U RATIO - **RI RATIO**

FOLLOW UP

B .Wt – Apgar NICU Care >24 Hrs

Mode Of Delivery Date Of Delivery Perinatal Death

INFORMED CONSENT FORM

Title of the study**:" Color doppler evaluation of cerebral umbilical pulsatility ratio and its usefulness in the diagnosis of intra uterine growth retardation and prediction of adverse perinatal outcome**".

Name of the Participant: DATE

AGE SEX IP NO

I have read the information in this form (or it has been read to me).
I have read and understood this consent form and the information provided to me.
I have had the consent document explained to me.
I have been explained about the nature of the study.
I have been explained about my rights and responsibilities by the investigator.
I have been explained that there s no risks associated with my participation in this study.*
I am aware of the fact that I can opt out of the study at any time without having to give any reason and this will not affect my future treatment in this hospital. *
I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without my consent. *
I hereby give permission to the investigators to release the information obtained from me as result of participation in this study . I understand that they are publicly presented.
I have understand that my identity will be kept confidential .
I have had my questions answered to my satisfaction.
I have decided to be in the research study.
By signing this consent form I attest that the information given in this document has been clearly explained to me and understood by me, I will be given a copy of this consent document.

Name _____ Signature_____

PATIENT COPY

Name: SI NO:

Sex: Age:

INTERPRETATION:

	First visit	After 2 weeks
UMBLICAL ARTERY PI		
MCA PI		
U/C RATIO		

MASTER CHART
EXPERIMENTAL CASES

NAME	AGE	GRAVIDA	MCA SD RATIO	UMB SD RATIO	PERCENTILE UMB SD RATIO	MCA RI	PERCENTILE
KOWSALYA	23	G1	3.5	3.8	>95TH	0.71	N
MAHALAKSHMI	26	G2	3.3	3.7	>95TH	0.7	N
NIRMALA	23	G1	2.65	6.05	>95TH	0.62	<5TH
MANJUPRIYA	21	G1	3.1	5.9	>95TH	0.68	N
JAYANTHI	29	G3A1L1	2.3	3.9	>95TH	0.58	N/<5TH
PADMAPRIYA	24	G1	4.2	2.4	N	0.85	N
ARUNA	24	G1	2.6	2.2	N	0.62	N
MANJULA	19	G1	2	3	N	0.51	N
CAROLIN	35	G2L0	3.8	2.7	N	0.62	N
PADMAPRIYA	23	G1	4.2	2.4	N	0.77	N
ABIRAMI	25	G2L1	3.9	2.6	N	0.75	N
UNNAMALAI	22	G1	4.8	2.8	N	0.77	N
AYISHA	24	G2	2.9	2.2	N	0.66	N

NAME	AGE	GRAVIDA	MCA SD RATIO	UMB SD RATIO	PERCENTILE UMB SD RATIO	MCA RI	PERCENTILE
DEVI	26	G2L1	2.8	2.3	N	0.64	N
SARANYA	26	G3L1	4.5	1.9	N	0.78	N
SANGEETHA	28	G2L1	7.5	2.5	N	0.86	>95TH
KUMUTHA	35	G1	5	3	N	0.74	N
KAVITHA	26	G2L1	5.4	3.3	N	0.82	N
LAXMI	24	G3L0	4	2.2		0.74	N
ANTHONIA	24	G1	8.5	5	>95TH	0.88	N
OSEELA	23	G1	6.8	4.9	>95TH	0.85	N
POONGODI	23	G1	4.1	2.1	N	0.74	N
RAJESWARI	25	G2L1	4	2.89	N	0.75	N
SHANTHI	26	G2L0	4.6	2.5	N	0.79	N
UNNAMALAI	25	G2L1	4.4	2.2	N	0.77	N
TAMILARASI	30	G3L1	5.9	4	>95TH	0.83	N
MADAVI20	20	G1	6.5	2.5	N	0.84	N
PARVATHI	27	G2	5.5	2.3	N	0.82	N
MEGALA	35	G2L1 OK	3.7	2.5	N	0.62	N

EXPERIMENTAL CASES

UMB RI	PERCENTILE	RI RATIO	MCA PI	PERCENTILE	UMB PI	PERCENTILE	PI RATIO	PI RATIO	APO	LSCS
0.74	>95TH	0.95	1.31	N	1.5	>95TH	0.86	<1	yes	LSCS
0.73	N	0.95	1.27	<5th	1.3	>95TH	0.97	<1	yes	LSCS
0.83	>95TH	0.74	1.09	<5th	1.62	>95TH	0.67	<1	yes	LSCS
0.83	>95TH	0.81	1.13	<5th	1.63	>95TH	0.69	<1	yes	LSCS
0.75	>95TH	0.77	0.99	<5th	1.4	>95TH	0.7	<1	yes	LSCS
0.61	N	1.39	1.64	N	1.82	>95TH	0.9	<1	yes	LSCS
0.56	N	1.1	0.92	<5th	0.99	N	0.92	<1 .	no	NVD
0.67	N	0.76	0.77	<5th	1.04	N	0.74	<1.	yes	NVD
0.57	N	1.1	0.96	<5th	0.9	N	1	<1.08	yes	NVD
0.61	N	1.39	1.68	N	1.82	>95TH	0.9	<1	yes	LSCS
0.62	N	1.2	1.65	N	0.97	N	1.7	>1	no	LSCS
0.65	N	1.18	1.53	N	1.05	N	1.45	>1	yes	LSCS
0.56	N	1	1	<5TH	0.8	N	1.25	>1	no	NVD
0.62	N	1.03	1.08	N/<5TH	1.08	N	1	>1	no	NVD

UMB RI	PERCENTILE	RI RATIO	MCA PI	PERCENTILE	UMB PI	PERCENTILE	PI RATIO	PI RATIO	APO	LSCS
0.47	<5TH	1.65	1.55	N	0.64	<5TH	2.4	>1	no	LSCS
0.61	N	1.4	2.2	N	1	N	2.2	>1	no	NVD
0.99	>95TH	0.8	1.34	N	0.62	<5TH	2.1	>1	no	LSCS
1.16	>95TH	0.7	1.66	N	0.71	N	2.2	>1	yes	LSCS
0.72	N	1	1.35	N/<5TH	1.22	>95TH	1.1	>1 .	yes	LSCS
0.8	>95TH	1.1	2	N	1.3	>95TH	1.5	>1.	yes	LSCS
0.8	>95TH	1.06	2.15	N	1.55	>95TH	1.3	>1.	no	LSCS
0.53	N	1.3	1.23	N	0.75	N	1.64	>1.	yes	LSCS
0.65	N	1.15	1.4	N	1.05	N	1.3	>1.	no	NVD
0.59	N	1.3	1.58	N	0.93	N	1.6	>1.	no	NVD
0.56	N	1.37	1.79	N	0.75	N	2.3	>1.	yes	LSCS
0.75	>95TH	1.1	1.8	N	1.2	>95TH	1.5	>1. .	no	LSCS
0.61	N	1.3	1.8	N	1	N	1.8	>1. .	yes	LSCS
0.58	N	1.4	1.7	N	0.9	N	1.8	>1. .	no	NVD
0.57	N	1.1	0.96	<5th	0.9	N	1	<1.08	yes	LSCS

CONTROL

CONTROL NAME	AGE	GRAVIDA	MCA SD RATIO	UMB SD RATIO	PERCENTILE	MCA RI	PERCENTILE
AMUTHA	24	G1	2.8	5.6	>95	0.65	N
ANANDHI	27	G1	17	2.4	N	0.95	N
SHOBANA	19	G2L0	5.8	2.4	N	0.83	N
SUGANTHI	29	G2L1 OK	4.2	3.3	N	0.77	N
STELLAMARY	25	G2L1	5.8	2.2	N	0.8	N
JAYACHITHRA	28	G1	7.9	3.5	N	0.87	N
MANI	23	G2	3.6	2.1	N	0.81	N
VENI	26	G2	6.4	2.3	N	0.78	N
SANDANYA	23	G1	6.5	2.7	N	0.69	N
SHANTHA	21	G1	6.4	2.9	N	0.8	N
SARASWATHI	29	G2 A1	8.2	2.6	N	0.8	N
VASANTHA	24	G2	8.3	2.6	N	0.61	N
KANI	24	G1	3	4.1	>95	0.74	N
SANGEETHA	19	G1	6.5	2.75	N	0.74	N

CONTROL NAME	AGE	GRAVIDA	MCA SD RATIO	UMB SD RATIO	PERCENTILE	MCA RI	PERCENTILE
THILLAI	35	G2L0	3.2	4.3	>95	0.65	N
RAJI	35	G2L1 OK	6.5	4.4	>95	0.76	N
NANCY	25	G2L1	4.5	2.7	N	0.74	N
VEENA	22	G1	3.7	4.6	>95	0.77	N
PRIYA	24	G2L0	3.8	2.2	N	0.83	N
VAISHNAVI	26	G2L1	4.6	2.4	N	0.76	N
SHANMUGAPRIYA	26	G3L1	6.7	4.5	>95	0.78	N
MEENAKSHI	28	G2L1	6.7	2.4	N	0.69	N
VISHALAKSHI	35	G2L0	8.4	4.9	>95	0.71	N
VAISHALI	26	G2L1	6.7	1.94	N	0.85	N
MUNIYAMMAL	24	G3L0	6.4	2.1	N	0.77	N
THYLAGAVATHI	24	G1	8.4	2.3	N	0.76	N
SHANTHI	23	G1	5.5	2.5	N	0.64	N
GOWRI	23	G1	6.3	3.1	N	0.82	N
HARINI	25	G2L1	4.7	3.2	N	0.72	N

UMB RI	PERCENTILE	RI RATIO	MCA PI	PERCENTILE	UMB PI	PERCENTILE	PI RATIO	PI RATIO	APO	LSCS
0.82	>95TH	0.79	1.2	<5TH	1.5	>95TH	0.8	<1	N	LSCS
0.59	<5TH	1.6	3.5	>95	0.94	N	3.7	>1	N	LSCS
0.59	<5TH	1.4	1.9	N	0.8	N	2.3	>1	N	NVD
0.7	N	1.1	1.3	N	1.27	>95TH	1	>1	N	NVD
0.56	<5TH	1.4	2	N	0.83	N	2.4	>1	N	LSCS
0.72	N	1.2	2.4	N	1.3	>95TH	1.8	>1	N	LSCS
0.56	N	1.4	1.8	N	0.74	N	2.43	>1	N	NVD
0.53	N	1.4	1.66	N	0.78	N	2.1	>1	Y	LSCS
0.67	N	1	1.58	N	0.8	N	1.97	>1	N	LSCS
0.7	N	1.1	1.9	N	0.76	N	2.5	>1	N	NVD
0.71	N	1.1	1.53	N	0.82	N	1.8	>1	N	NVD
0.6	N	1.01	2.1	N	0.86	N	1.8	>1	N	LSCS
0.73	>95TH	1	1.3	<5TH	1.3	>95TH	1	1	Y	LSCS
0.48	N	1.5	2.2	N	0.75	N	2.9	>1	N	NVD

UMB RI	PERCENTILE	RI RATIO	MCA PI	PERCENTILE	UMB PI	PERCENTILE	PI RATIO	PI RATIO	APO	LSCS
0.79	>95TH	0.8	1.4	<5TH	1.7	>95TH	0.8	<1	Y	NVD
0.78	>95TH	0.97	1.2	<5TH	1.5	>95TH	0.8	<1	N	NVD
0.8	>95TH	0.9	1.34	<5TH	1.4	>95TH	0.95	<1	Y	LSCS
0.81	>95TH	0.95	1.31	<5TH	1.6	>95TH	0.8	<1	N	LSCS
0.5	N	1.6	2.3	N	0.84	N	2.7	>1	N	NVD
0.51	N	1.4	2.2	N	0.86	N	2.5	>1	N	NVD
0.72	>95	1.08	1.33	<5TH	1.4	>95TH	0.95	<1	N	NVD
0.48	N	1.4	2.2	N	0.87	N	2.5	>1	N	NVD
0.5	N	1.42	1.1	<5TH	0.91	N	1.2	>1	N	NVD
0.52	N	1.6	1.32	<5TH	0.92	N	1.4	>1	N	LSCS
0.57	N	1.35	3.6	>95	0.94	N	3.8	>1	N	LSCS
0.59	N	1.28	1.7	N	0.96	N	1.7	>1	Y	LSCS
0.6	N	1.06	1.47	N	0.97	N	1.5	>1	N	LSCS
0.5	N	1.64	1.6	N	0.98	N	1.6	>1	N	NVD
0.52	N	1.38	1.4	N	0.98	N	1.4	>1	N	NVD

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To

Dr.Dheebha.V.
Post Graduate Degree in Radio Diagnosis
Madras Medical College
Chennai 600 003

Dear Dr.Dheebha.V.

The Institutional Ethics Committee has considered your request and approved your study titled **"COLOR DOPPLER EVALUATION OF CEREBRAL - UMBLICAL PULSATILITY RATIO AND ITS USEFULLNESS IN THE DIAGNOSIS OF INTRA UTERINE GROWTH RETARDATION AND IN PREDICTION OF ADVERSE PERINATAL OUTCOME "** NO.20032015.

The following members of Ethics Committee were present in the meeting hold on 03.03.2015 conducted at Madras Medical College, Chennai 3

1. Prof.C.Rajendran, MD	:Chairperson
2. Prof.R.Vimala,MD.,Dean,MMC,Ch-3	: Deputy Chairperson
3. Prof.B.Kalaiselvi,MD.,Vice Principal,MMC,Ch-3	: Member Secretary
4. Prof.R.Nandini,MD.,Inst.of Pharmacology,MMC	: Member
5. Prof.K.Ramadevi, Director I/c,Inst.of Bio-Chem.MMC	: Member
6. Prof.Saraswathy,MD.,Director,Pathology, MMC	: Member
7. Prof.S.G.Sivachidambaram,MD.,Director I/c Inst.of Internal Medicine,MMC	: Member
8. Thiru S.Rameshkumar, B.Com., MBA.	: Lay Person
9. Thiru S.Govindasamy, BA., BL.,	: Lawyer
10.Tmt.Arnold Saulina, MA., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary - Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

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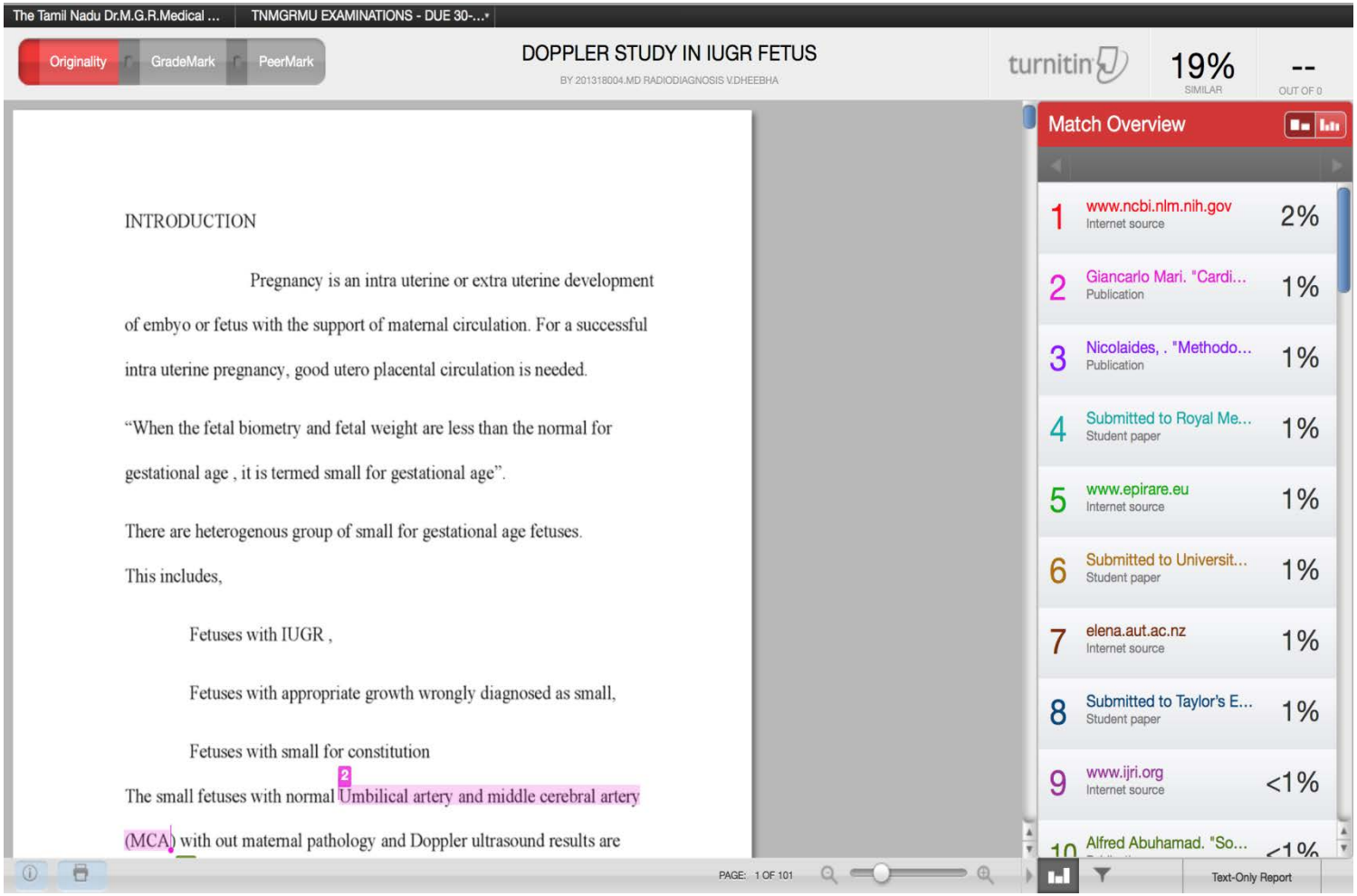
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INTRODUCTION
Pregnancy is an intra uterine or extra uterine development of embyo or fetus with the support of maternal circulation. For a successful intra uterine pregnancy, good utero placental circulation is needed.
"When the fetal biometry and fetal weight are less than the normal for gestational age , it is termed small for gestational age".
There are heterogenous group of small for gestational age fetuses.
This includes,
Fetuses with IUGR ,
Fetuses with appropriate growth wrongly diagnosed as small,
Fetuses with small for constitution
The small fetuses with normal Umbilical artery and middle cerebral artery (MCA) with out maternal pathology and Doppler ultrasound results are
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